

Summary of the 51st Session of the Intergovernmental Panel on Climate Change: 20-24 September 2019

On Tuesday afternoon, 24 September 2019, the 51st session of the Intergovernmental Panel on Climate Change (IPCC-51) adopted the Summary for Policymakers (SPM) of the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) and accepted the underlying report.

The SROCC assesses the latest scientific knowledge about the physical science basis for, and impacts of, climate change on ocean, coastal, polar, and mountain ecosystems, and the human communities that depend on them. It also evaluates their vulnerabilities and adaptation capacity, as well as options for achieving climate-resilient development pathways.

The report has some alarming messages. The global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system. As IPCC Vice-Chair Ko Barrett said during the press conference that launched the report to the public, “Water is the lifeblood of the planet” and the world’s ocean and cryosphere have been “taking the heat” from climate change for decades, with “sweeping and severe” consequences for nature and humanity.

The report highlights the urgency of prioritizing action to address “unprecedented” and enduring changes in the ocean and cryosphere. It indicates that with any degree of additional warming, events that historically occurred once per century will occur every year by mid-century in many regions. Recent hurricanes in the Caribbean, for example, are a testament to this.

While sea level rise is currently rising more than twice as fast now as during the 20th century and accelerating, the report notes a projected rise by 30-60 cm more by 2100 even if emissions significantly decrease and temperature rise is limited to below 2°C. This figure will be much greater if emissions continue to rise unabated. In addition, as mountain glaciers retreat, they are also altering water availability and quality downstream, with implications for many sectors, including agriculture and hydropower.

The SROCC was prepared by 104 authors from 36 countries, 31 of which are women, and 19 from developing countries or countries with economies in transition. The report includes over 6,981 cited references. The author team considered 31,176 comments from expert reviewers and governments in 80 countries, including 3,037 on the Final Government Draft. It was prepared under the joint leadership of Working Groups (WGs) I and II, with support from the WG II Technical Support Unit (TSU).

IPCC-51 convened from 20-24 September 2019 in Monaco and brought together more than 400 participants from over 114 countries and observer organizations. Although the meeting was initially scheduled to end on 23 September, it went through the night and concluded after 1:30 pm on the following day. The meeting was hosted by the Government of Monaco and the Prince Albert II of Monaco Foundation.

A Brief History of the IPCC

Origins and Structure of the IPCC

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the UN Environment Programme (UNEP) to assess, in a comprehensive, objective, open, and transparent manner, the scientific, technical, and socio-economic information relevant to understanding human-induced climate change, its potential impacts, and adaptation and mitigation options. The IPCC is an intergovernmental and scientific body with 195 member countries. It does not undertake new research or monitor climate-related data; rather, it conducts assessments of the state of climate change knowledge on the basis

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of published and peer-reviewed scientific and technical literature. IPCC reports are intended to be policy relevant, but not policy prescriptive.

The IPCC has three Working Groups:

- Working Group I (WG I) addresses the physical science basis of climate change.
- Working Group II (WG II) addresses climate change impacts, adaptation and vulnerability.
- Working Group III (WG III) addresses options for reducing greenhouse gas (GHG) emissions and mitigating climate change.

Each WG has two Co-Chairs and seven Vice-Chairs, with the exception of WG II, which has eight Vice-Chairs. The Co-Chairs guide the WGs in fulfilling the mandates given to them by the Panel with the assistance of Technical Support Units (TSUs).

In addition, the IPCC also has a Task Force on National Greenhouse Gas Inventories (TFI) to oversee the IPCC National GHG Inventories Programme, which is also supported by a TSU. The Programme's aims are to develop and refine an internationally-agreed methodology and software for calculating and reporting national GHG emissions and removals, and to encourage its use by parties to the UN Framework Convention on Climate Change (UNFCCC).

The Panel elects its Bureau for the duration of a full assessment cycle, which includes preparation of an IPCC assessment report that takes around seven years. The Bureau is composed of climate change experts representing all regions, and includes the IPCC Chair and Vice-Chairs, WG Co-Chairs and Vice-Chairs, and TFI Co-Chairs. The IPCC has a permanent Secretariat, which is based in Geneva, Switzerland, and is hosted by the WMO.

IPCC Products

Since its inception, the Panel has prepared a series of comprehensive assessment reports, special reports (SRs), and technical papers that provide scientific information on climate change to the international community.

The IPCC has produced five assessment reports, which were completed in 1990, 1995, 2001, 2007, and 2014. The Sixth Assessment Report (AR6) is expected to be completed in 2022. The assessment reports are structured in three parts, one for each WG. Each WG's contribution comprises an SPM, a Technical Summary, and the full underlying assessment report. Each of these reports undergoes an exhaustive and intensive review process by experts and governments, involving three stages: a first review by experts, a second review by experts and governments, and a third review by governments. Each SPM is then approved line-by-line by the respective WG.

A Synthesis Report (SYR) is produced for the assessment report as a whole and integrates the most relevant aspects of the three WG reports and SRs of that specific cycle. The Panel then undertakes a line-by-line approval of the SPM of the SYR.

The IPCC has also produced a range of SRs on climate change-related issues. The sixth assessment cycle includes three Special Reports:

- Global Warming of 1.5°C (SR15), which was approved by IPCC-48 in October 2018;
- Climate Change and Land (SRCCL), which was approved by IPCC-50 in August 2019; and
- Ocean and Cryosphere in a Changing Climate (SROCC), which was approved by IPCC-51 in September 2019.

In addition, the IPCC produces methodology reports, which provide guidelines to help countries report on GHGs. Good Practice Guidance reports were approved in 2000 and 2003, while

the IPCC Guidelines on National GHG Inventories was approved in 2006. A Refinement to the 2006 Guidelines on National GHG Inventories (2019 Refinement) was adopted at IPCC-49 in May 2019.

In 2007, the Nobel Peace Prize was jointly awarded to the IPCC and former US Vice President Al Gore, for their work and efforts "to build up and disseminate greater knowledge about manmade climate change, and to lay the foundations needed to counteract such change."

Sixth Assessment Cycle

IPCC-41 to IPCC-43: IPCC-41 (24-27 February 2015, Nairobi, Kenya) adopted decisions relevant to the sixth assessment cycle. IPCC-42 (5-8 October 2015, Dubrovnik, Croatia) elected Bureau members for the sixth assessment cycle. IPCC-43 (11-13 April 2016, Nairobi, Kenya) agreed to undertake two SRs (SRCCL and SROCC) and the 2019 Refinement during the sixth assessment cycle, and, in response to an invitation from the 21st session of the Conference of the Parties to the UNFCCC (COP 21), to prepare an SR in 2018 on the impacts of limiting global warming of 1.5°C above pre-industrial levels (SR15). The Panel also agreed that an SR on cities would be prepared as part of the seventh assessment cycle.

IPCC-44: During this session (17-21 October 2016, Bangkok, Thailand), the Panel adopted outlines for SR15 and the 2019 Refinement, as well as decisions on, *inter alia*, a meeting on climate change and cities.

IPCC Cities and Climate Change Science Conference:

This meeting (5-7 March 2018, Edmonton, Canada) produced a research agenda to better understand climate change's impacts on cities and the critical role local authorities can play in addressing it.

IPCC-45 to IPCC-47: IPCC-45 (28-31 March 2017, Guadalajara, Mexico) approved the SRCCL and SROCC outlines, and discussed, *inter alia*: the strategic planning schedule for the sixth assessment cycle; a proposal to consider short-lived climate forcers (SLCFs); and resourcing options for the IPCC. IPCC-46 (6-10 September 2017, Montreal, Canada) approved the chapter outlines for the three WG report contributions to AR6.

During IPCC-47 (13-16 March 2018, Paris, France), the Panel agreed to, *inter alia*: establish a task group on gender; draft terms of reference for a task group on the organization of the future work of the IPCC in light of the Global Stocktake under the Paris Agreement; and expand the IPCC Scholarship Programme to include funding for chapter scientists.

IPCC-48: During this session (1-6 October 2018, Incheon, Republic of Korea), the IPCC accepted SR15 and its Technical Summary and approved its SPM. A Joint Session of the WGs considered the SPM line-by-line to reach agreement, representing the first time the three WGs had worked together in an interdisciplinary fashion on an IPCC SR. The SPM concludes, *inter alia*, that limiting global average temperature rise to 1.5°C is still possible, but will require "unprecedented" transitions in all aspects of society.

IPCC-49: During this session (8-12 May 2019, Kyoto, Japan), the IPCC adopted the Overview Chapter of the 2019 Refinement and accepted the underlying report. Issues addressed include the relationship with the 2006 IPCC Guidelines, and new developments in the 2019 Refinement.

IPCC-49 also adopted decisions on the terms of reference for the Task Group on Gender, and on a methodological report on SLCFs to be completed during the seventh assessment cycle.

IPCC-50: During this session (2-7 August 2019, Geneva, Switzerland), the IPCC accepted the SRCLL and its Technical Summary and approved its SPM. A Joint Session of the WGs, in cooperation with the TFI, considered the SPM line by line to reach agreement.

Reports of IPCC-51 and the Second Joint Session of WGs I and II

IPCC Secretary Abdalah Mokssit welcomed His Serene Highness Prince Albert II of Monaco and participants to IPCC-51 on Friday morning, 20 September 2019. He thanked the Government of Monaco and the Prince Albert II of Monaco Foundation for their generous financial and scientific support to the IPCC, including to the IPCC Scholarship Programme for young developing country scientists, and encouraged other delegations to follow Monaco's example.

IPCC Chair Hoesung Lee called the SROCC a major milestone in a marathon year for the IPCC, thanking everyone involved. He said the four reports completed during the 2018-2019 period would help galvanize action at the UN Secretary-General's Climate Action Summit on 23 September and the 25th meeting of the Conference of the Parties to the UNFCCC (COP 25).

WMO Deputy Secretary-General Elena Manaenkova highlighted the WMO's ocean- and cryosphere-related work, including: establishment of the Global Cryosphere Watch; the WMO's upcoming High Mountain Summit in October; establishment of a collaborative framework for the ocean at the 2019 WMO Congress; and a new regional climate center in Antarctica.

Via video message, UNEP Executive Director Inger Andersen described known challenges for the ocean and cryosphere, including threatened coral reefs, depleted fish stocks, plastic waste flows, rising sea levels, glacier loss, and thawing permafrost. However, she also highlighted the opportunity to change course, and underlined the importance of IPCC-51's work, arguing that any solutions are only as good as the science.

Florin Vladu, Manager, Adaptation Programme, UNFCCC, welcomed the IPCC's work as critical to the broader process of strengthening climate action, noting that the SROCC will inform and support the next round of Nationally Determined Contributions (NDCs) under the UNFCCC, 60% of which he said already include reference to ocean-related adaptation and mitigation actions.

Andrés Couve Correa, Minister of Science, Technology and Innovation, Chile, underscored knowledge sharing and coordinated action to address climate change. He highlighted Chile's support for Antarctic research, its large percentage of marine protected areas, and its commitment to replace coal by 2040 and become carbon neutral by 2050. He noted the relevance of the SROCC for COP-25 as "the Blue COP," which will be held in Santiago, Chile, in December. He added that the IPCC's work responds to growing public expectations, enhancing the link between scientific evidence, and climate action.

His Serene Highness Prince Albert II of Monaco stressed the importance of the Panel in terms of its transparency and scientific expertise. Highlighting political obstacles to tackling climate change, including the pursuit of selfish short-term interests, he called for urgent action based on a rigorous, balanced scientific approach that can help those who want to defend the environment. He stressed the need to convince everyone to act together. He emphasized the priority of reducing emissions, stressed that the world needs clarity on impacts and on options for

action and, quoting the oceanographer Sylvia Earle, said "It is the worst of times, but also the best of times because we still have a chance."

Approval of the Provisional Agenda: Chair Lee introduced the provisional agenda (IPCC-LI/Doc.1, Add.1) and the proposed organization of work (IPCC-LI/INF.1).

France voiced solidarity with the Bahamas in the aftermath of its recent cyclone, noting that the event illustrates the importance of the IPCC and SROCC.

There were numerous requests for discussion of issues under Other Business:

- France, Belgium, and the UK requested updates on the SYR process, author selection, and TSU recruitment;
- Saudi Arabia called for discussing the balance between developed and developing countries in the selection of scientists for the SYR, suggesting that scientists from the South living in the North should not be considered "Southern" scientists;
- France also requested an update of progress on translation of SR15 into the six UN languages;
- the UK requested information regarding progress made by the Task Group on Data Support for Climate Change Assessments (TG-Data); and
- Zimbabwe reiterated his call, made during IPCC-50, to discuss convening special developing country briefings on key issues, in order to assist small delegations to engage more meaningfully in the process.

On the understanding that these items would be taken up as suggested, the agenda and organization of work were then approved.

China urged the Co-Chairs to guide IPCC-51's work according to the IPCC Principles and Procedures.

Anne Larigauderie, Executive Secretary, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), addressing the IPCC for the first time, recalling the recent approval of the Global Assessment Report on Biodiversity and Ecosystem Services, which found that biodiversity is being lost at an unprecedented rate and scale. She noted that climate change is one of five major drivers of biodiversity loss, and that properly managed ecosystems can contribute to climate mitigation, underscoring the need to jointly address climate change and biodiversity. She recalled the request by the IPBES plenary for joint activities, including a joint paper to inform both UNFCCC COP 25 and the 15th meeting of the Convention on Biological Diversity Conference of the Parties (CBD COP 15).

Adoption of the IPCC-50 Report: IPCC Chair Lee then opened the floor for approval of the draft report of IPCC-50 (IPCC-LI/Doc.2, Rev.1), which he noted had been revised in light of comments received.

Switzerland suggested that the section on collaboration between IPCC and IPBES should focus on concrete next steps in organizing the joint efforts called for by IPBES Executive Secretary Larigauderie.

Zimbabwe noted that his suggestion for special developing country sessions on key IPCC issues, which was supported by Jamaica, did not appear in the report.

Belgium noted her intervention at IPCC-50 on the need for shorter SPMs of around 10 pages and asked that this suggestion be reflected in the report.

Chair Lee agreed to incorporate the suggested changes, and the draft report was accepted with that understanding. He then suspended IPCC-51 until Tuesday afternoon to allow the second Joint Session of WGs I and II to begin work.

Consideration and Approval of the SROCC SPM

Opening of the Joint Session of WGs I and II: WG II

Co-Chair Debra Roberts opened the session on Friday morning, recalling that SROCC is the end of a long journey that began three years ago when the Panel decided to prepare three SRs for the sixth assessment cycle. The Joint Session then adopted its agenda (WG-I & WG-II: 2nd/Doc. 1).

WG II Co-Chair Hans-Otto Pörtner introduced the SROCC. Recognizing that the SPM was longer than anticipated and time to go through the report was limited, he called for focused and short interventions.

Japan and Ecuador noted that the length of the report exceeds what was agreed in the outline and called for avoiding this in the future.

Delegates then began approving, line by line, the SPM, which includes three sections on observed changes and impacts, projected changes and risks, and implementing responses to ocean and cryosphere change. For each subsection, they first reviewed the headline statement, then agreed on the paragraphs within that subsection, before going back to agree on the headline statement. Difficult issues were delegated to huddles and contact groups, where government representatives and authors discussed text before bringing proposals back to plenary.

Introduction: This section provides an overview of the origins of the SROCC and the SPM structure and was agreed as presented with minor amendments for clarity and for consistency with the SROCC underlying report.

Startup Box: The Importance of the Ocean and Cryosphere for People: This box was first taken up on Friday and was agreed on Saturday. Regarding a sentence on projected responses of the ocean and cryosphere to past and current human-induced GHG emissions and ongoing global warming, France requested reference to feedback sources in the climate system, highlighting snow and ice in particular. Following a suggestion by authors to mention climate feedback processes more generally, the sentence was agreed.

On a sentence on human communities closely connected with coastal environments, polar areas, and high mountains, Trinidad and Tobago, supported by Saint Kitts and Nevis, Grenada, the Maldives, Fiji, Haiti, and Australia, called for elevating reference to small island developing states (SIDS) from a footnote to the main text, and for stating that SIDS include 50 countries and territories with over 60 million people and special economic, social, and environmental vulnerabilities.

Saint Kitts and Nevis lamented the Bahamas' absence because of Hurricane Dorian. Bolivia called for reference to Indigenous peoples living in the Andes. Tanzania stressed climate change's negative impacts on glaciers in high mountains of Africa.

Zimbabwe called for reference to landlocked countries affected by droughts and extreme weather events caused by ocean and cryosphere changes. Authors responded that landlocked countries are covered by a statement elsewhere that all people on earth depend on the oceans and cryosphere; however, Zimbabwe, eSwatini, and Tanzania distinguished dependency from vulnerability to impacts of ocean changes.

Ecuador, supported by India, called for including the percentage of the population that is indigenous in a footnote describing high mountain areas.

A huddle, facilitated by IPCC Vice-Chair Youba Sokona, further considered these issues, and revised text was presented on Saturday morning. In the revised text, reference to small islands, including SIDS, was added to a list of human communities affected by changes. The group also approved sentences stating

that: around four million people live in the Arctic, of whom 10% are indigenous; the low-lying coastal zone is home to around 680 million people, with more than one billion projected by 2050; and SIDS are home to 65 million people.

A new statement proposed by the huddle sought to address Zimbabwe's concern by noting that communities further from the coast are also exposed to changes in the ocean, such as through extreme weather events.

Reference to Indigenous peoples was added to a statement that around 670 million people live in high mountain regions in all continents except Antarctica. A statement projecting a range of Indigenous population numbers in 2050 was approved.

Footnotes on calculation of population in the low elevation coastal zone and in high mountain regions were also approved.

In response to comments from the European Union (EU) and Switzerland, a paragraph on services was reorganized to distinguish between two types of services provided to people by the ocean and cryosphere: those related to climate change, such as carbon uptake, and those unrelated to climate change, such as food and water supply. Belgium suggested that it might be an overstatement to assert that the ocean and cryosphere interact with each aspect of sustainability reflected in the Sustainable Development Goals (SDGs). However, the authors responded that the statement was accurate in that it covered not just impacts of the ocean and cryosphere on the SDGs but also the impact of SDG progress on capacity to address challenges described in the SROCC.

Final Text: The final text of the **introduction** states that the SROCC was prepared following an IPCC Panel decision in 2016 to prepare three SRs during the sixth assessment cycle. It notes that the SROCC follows the SR15 and SRCLL, as well as the IPBES Global Assessment Report on Biodiversity and Ecosystem Services.

The introduction outlines the SPM's three-part structure, namely: observed changes and impacts; projected changes and risks; and implementing responses to ocean and cryosphere change. It explains that icons indicate where content can be found to assist navigation of the SPM, namely for the high mountain cryosphere, polar regions, coasts and sea level rise, and ocean.

The introduction also explains that confidence in key findings is reported using IPCC calibrated language and the underlying scientific basis for each key finding is indicated by references to the relevant section of the underlying report.

A footnote in the introduction explains the assessed likelihood of an outcome or result, as follows: virtually certain 99-100% probability, very likely 90-100%, likely 66-100%, about as likely as not 33-66%, unlikely 0-33%, very unlikely 0-10%, and exceptionally unlikely 0-1%.

The **Startup Box** explains that all people on earth depend on the ocean and cryosphere directly or indirectly. It highlights in particular the exposure of communities connected to coasts, small island states, polar areas, and high mountains to phenomena, such as sea-level rise, extreme events, and shrinking cryosphere. And it notes the benefits for people of the ocean and cryosphere, including food and water supply, renewable energy, and benefits for health and well-being, cultural values, tourism, trade, and transport.

A: Observed Changes and Impacts

This section was first addressed on Friday morning and was discussed in plenary, contact groups, and informal huddles. It addresses observed physical changes, observed impacts on ecosystems, and observed impacts on people and ecosystem services.

Observed Physical Changes: A1. This subsection addresses **cryosphere shrinking**, including mass ice sheet and glacier loss, reductions in snow cover and Arctic sea ice extent and thickness, and increased permafrost temperatures. On the headline statement, Canada suggested changing reference to “permafrost thaw” to “increased permafrost temperatures” for clarity. This was accepted and the headline statement agreed.

A1.1: On a paragraph on **mass loss of ice sheets and glaciers worldwide**, suggestions were made to improve the clarity of the numbers and their equivalent in sea level rise. Authors proposed adding a footnote on the conversion rates of gigatons of ice loss and global mean sea level (GMSL). An additional footnote clarifying that the numbers include glaciers peripheral to both the Greenland and Antarctic ice sheets was also agreed.

In response to a proposal by Saudi Arabia to refer to the more recent period 2012-2016 as in the underlying report, authors stated their preference for longer 10-year time periods for reliability. With the addition of the two footnotes, the text was agreed as presented.

A1.2: This paragraph addresses **declining extent and duration of snow cover**. Regarding a sentence on decline in Arctic June snow cover extent on land, the EU, Switzerland, and others suggested adding the equivalent in land surface of the snow cover decline to enhance clarity of the message. Various countries also called for inclusion of statements from the previous draft referring to the more than double increase in Arctic surface air temperature relative to the global average. Authors confirmed that this issue would be taken up in the paragraph on Arctic sea ice extent.

A1.3: This paragraph addresses **increased permafrost temperatures since the 1980s**. Regarding the recent average increase by $0.29 \pm 0.12^\circ\text{C}$ from 2007 to 2016 across polar and high mountain regions, Spain, supported by India and Canada, suggested describing regional variations. The sentence was modified to clarify that the data are averages across polar and high mountain regions globally. Objecting to the averaging of high mountain regions, India asked for differentiation for the Himalayas in particular, with the authors responding that insufficient data exists on Himalayan permafrost.

The European Marine Board, supported by Finland, pointed to the importance of marine methane as a GHG with 25 times more global warming potential than carbon dioxide, and asked for additional text to reflect this. However, the paragraph was approved without this addition.

A1.4: This paragraph addresses the **decrease in Arctic and Antarctic sea ice extent**. In response to a suggestion by Saudi Arabia and questions on confidence levels related to decreases in Arctic sea ice extent, authors agreed to reformulate a “very high confidence” statement to reflect a “very likely” decrease in Arctic sea ice extent. Some countries questioned the change, but Co-Chair Pörtner explained that this is a statistical statement.

Authors also agreed to add reference to the role of snow cover, as suggested by France.

On a sentence addressing feedbacks from the loss of sea ice and consequences for mid-latitude weather, Norway, the Russian Federation, the US, Germany, and India requested clearer reference to teleconnections, i.e., climate anomalies related to each other at large distances. The authors proposed, and the group agreed, to state that changes in Arctic sea ice have the potential to influence mid-latitude weather, but there is low confidence in the detection of this influence for specific weather types.

On a sentence on changes in Antarctic sea ice extent changes, the UK and Australia suggested adding reference to notable changes observed more recently, but authors said that 2016-2018 was too short a time period to suggest a clear attribution to

climate change as opposed to just climate variability. Instead, they proposed stating that Antarctic sea ice extent overall has had no statistically significant trend, due to contrasting regional signals and large interannual variability.

With these and other changes for consistency and clarity, the paragraph was agreed.

Figure SPM.1: Past and Future Changes in the Ocean and Cryosphere: This figure, which was first addressed on Friday afternoon, addresses observed and modeled historical changes in the ocean and cryosphere, and projected changes under low and high Representative Concentration Pathways (RCPs), namely RCP2.6 and RCP8.5, respectively.

Luxembourg, supported by the UK, France, Saint Kitts and Nevis, Belgium, the Netherlands, Germany, and Trinidad and Tobago, argued that the panel on GMSL rise would be more helpful to policymakers if it were extended to show projections up to 2300. India asked for the figure’s panels to be extended back in time to 1850. Japan asked that the panel on Arctic sea ice extent use relative, not absolute, percentage changes on the vertical axis, noting that the current formulation might mislead policymakers.

The EU noted that the panel on GMSL amounted to an aggregation of panels on ocean heat content and Greenland and Antarctic ice sheet loss, all of which are expressed in terms of sea level equivalent. He asked that this relationship be illustrated more clearly. The US also called for regrouping panels to better express their inter-relationships. Saudi Arabia, and Ecuador suggested that only reflecting the “extreme scenarios,”—that is RCP2.6 and RCP8.5—was misleading, and asked that a more realistic scenario, such as RCP4.5, be shown as well. The US, supported by Trinidad and Tobago, asked for a definition of marine heatwaves in this figure.

Following further work by authors, a revised version of the figure was presented on Saturday night. It incorporated a suggestion to include projected changes in GMSL until 2300, with hatching of the trend area to reflect greater uncertainty, and included: captions and footnotes to better explain the RCPs; visual and text aids to indicate the relationships among the panels; and percentage changes on the vertical axes of many of the panels.

Several countries, including Saint Kitts and Nevis and Germany, expressed full support for the revised version.

In response to Ecuador and Saudi Arabia, authors explained the lack of information on many RCP4.5 parameters. In response to India, authors said data earlier than 1950 show little change, so including them into the panels would compress the meaningful data, reducing the information value of the panels.

The figure was subsequently further revised to address Germany and France’s suggestion to insert more detail on GMSL around 2100 that had been lost in extending the timeframe until 2300. It was accepted on Monday without further revision.

Box SPM.1: Use of Climate Change Scenarios in SROCC: A new box on the use of scenarios in SROCC was introduced in response to government comments. Many countries, including Japan, the US, Germany, Sweden, Saudi Arabia, Luxembourg, Ireland, Denmark, Canada, India, and France, expressed concern with the level of complexity in the language and lack of clarity in the numbers included in the box as proposed. They called for: clearer traceability to the underlying report; explanation behind the choice of the two scenarios used; clarity on assumptions going into the two scenarios; and avoidance of simplistic assumptions linking the scenarios to particular emissions pathways.

Saudi Arabia also opposed references to SR15 and lower emissions scenarios used in that report and, with India, reiterated her call for information on mid-range scenarios.

Authors presented a revised version of the box. The authors explained changes made, including: broader descriptions of RCPs; a simplified table; references to other RCPs with intermediate levels of GHG emissions, where available; and links to other time periods.

There was lengthy discussion on other RCPs, particularly regarding a footnote stating that a pathway with even lower emissions (RCP1.9), which would increase the chances of limiting warming to 1.5°C, was not assessed due to lack of available literature. Saudi Arabia said that if RCP1.9 was mentioned as having not been assessed, similar mentions should be included throughout the SROCC about other RCPs. Germany, Belgium, Canada, France, Fiji, and others objected and supported a Co-Chairs' proposal to simply say that RCP1.9 was not included in the climate model projections on which the RCPs are based.

In response to a suggestion by Saudi Arabia to mention adaptation alongside mitigation, authors explained that RCPs only refer to GHG concentrations in the atmosphere. Saudi Arabia also questioned the use of the word "mitigation" when describing RCP8.5, and proposed to refer to RCP8.5 as a scenario "without climate change policies." Belgium, France, Germany, the UK, and others objected, saying the focus of that RCP is on the "absence of mitigation."

Saudi Arabia, opposed by France, Luxembourg, Canada, and others, also reiterated an objection to reference SR15, and requested that all knowledge gaps in that report be mentioned if the report was cited.

Discussions on the box continued in a huddle, which resulted in a revised box referring to "policies to combat climate change" instead of "mitigation," and without reference to SR15 and SRCCL. With these changes, Box SPM.1 was approved.

A2: This subsection addresses **ocean warming, marine heatwaves, ocean acidification, and ocean oxygen loss**. The headline statement was agreed, with the addition of clarifying language to reflect the trend in "increasing" acidification due to "more" CO₂, as suggested by Germany and the UK.

A2.1: This paragraph deals with **rate of ocean warming**. Finland, supported by Spain, the UK, and Estonia, questioned the use of zettajoules to express the extent of ocean warming, and suggested converting the figures to degrees centigrade to make the text more understandable. The authors explained that different levels of the ocean warm at different speeds, and that including temperature figures based on whole-ocean averages would be misleading.

Norway requested an introductory sentence on ocean warming trends, and Germany requested that it be attributed to anthropogenic forcing (GHGs and aerosols). The authors agreed to both requests.

A2.2: On a paragraph on **heat gain in the Southern Ocean**, India called for linkages to warming in the Indian Ocean, but authors favored keeping it as presented in the literature, which was agreed.

A2.3: Regarding a paragraph on **marine heatwaves**, authors agreed to Trinidad and Tobago's suggestion to refer to them as a subset of heat-related events and proposed adding a definition of marine heatwaves.

There was also discussion on attributing marine heatwaves to anthropogenic effects. Saudi Arabia preferred only referring to temperature increases since 1850-1900 without mention of attribution, while Norway stressed the importance of clarity on

anthropogenic effects. Authors proposed, and the group agreed, to refer to anthropogenic attribution of marine heatwaves.

A2.4: A paragraph on **ocean density stratification** was approved with minor revisions.

A2.5: On a paragraph discussing **ocean heat uptake and resulting acidification**, the US noted that data on the range of ocean pH reduction are drawn only from *in situ* records of longer than 15 years and requested this be made explicit in the text. This was agreed and the paragraph approved.

A2.6: Regarding a paragraph on **loss of ocean oxygen**, Canada suggested adding reference to expansion of "the volume" of oxygen minimum zones to improve clarity. This was accepted and the paragraph was approved.

A2.7: This paragraph discusses **weakening of the Atlantic Meridional Overturning Circulation (AMOC)**. Spain suggested appending a footnote defining the AMOC and referencing the glossary, and the authors agreed. Germany suggested specifying that the model results were driven by anthropogenic factors. Authors agreed and also proposed language that specified that the results derived from Coupled Model Intercomparison Project 5 (CMIP5) modeling. With additional minor changes, the paragraph and footnote were approved.

A3: This subsection addresses the **acceleration of GMSL rise and the exacerbation of extreme sea level events and coastal hazards**. Regarding the headline statement, India asked why prominence was given to the role of the Antarctic and Greenland Ice Sheets as accelerators, but not to glaciers. Authors explained that glacier mass loss and thermal expansion are not accelerators. Saint Kitts and Nevis requested language on tropical cyclones to give the issue more prominence since a new paragraph on cyclones had been added in this subsection. This was agreed. With another minor amendment, the paragraph was accepted.

A3.1: This paragraph addresses **unprecedented GMSL rise** over the last century. In response to Austria, the authors added a footnote explaining that the sum of GMSL rise from ice sheet melt and thermal expansion does not equal the total figure, due to land water storage. In response to Norway and the UK, a final sentence was added noting that the dominant cause of GMSL rise since 1970 is anthropogenic forcing. The paragraph was accepted as amended.

A3.2: A paragraph on the **acceleration of sea level rise due to ice loss from the Greenland and Antarctic Ice Sheets** was accepted with minor amendment.

A3.3: Regarding a paragraph on **acceleration of ice flow in Antarctica**, discussion centered on how to refer to the potential onset of irreversible ice sheet instability. Several countries, including Saint Kitts and Nevis, Germany, Belgium, the Netherlands, and Chile, underscored the importance of a clear message on potential irreversibility. Various formulations were attempted to convey that the statement's low confidence level was a result of: insufficient observations; inadequate model representation of ice sheet processes; and limited understanding of complex interactions between oceans and ice sheets. The Joint WG Session eventually agreed to language on the uncertainty of the assessment, and to a footnote on irreversibility explaining that the recovery time scale is hundreds to thousands of years in relation to irreversibility.

A3.4: This paragraph, on **regional variations in sea level rise**, engendered some confusion among delegates, who raised questions on: how to distinguish between sea level rise and vertical land movements; how to account for differences in variation between them; why each occurs; and examples of human activities that cause vertical land movement.

The authors attempted to address the concerns expressed, but this raised questions on whether the sentence refers to continuous sea level rise and whether glacial rebound is acknowledged. Germany and Luxembourg preferred referring to spatial, not temporal, scales. Following an informal huddle, revised text was presented and accepted without further comment.

A3.5: On this paragraph, which deals with **increased wave heights**, Tanzania and Spain asked for more clarity on how increasing wave heights are related to extreme sea level events. The authors responded that they are one of many aggravating factors, including tides, cyclones, and surges. Trinidad and Tobago, supported by Zimbabwe, Ecuador, Saint Kitts and Nevis, Tanzania, France, Jamaica, and Kenya, opposed treating tropical cyclones as a sub-issue in one sentence of this paragraph, noting that for many tropical states, cyclones are a critical threat, and reminded authors that ample information is available in the underlying text. He called for a separate paragraph on this issue, and for its inclusion in the section's headline statement. Zimbabwe said the impacts are felt not just by coastal states, noting the droughts caused in his country by recent coastal storms. Following huddle consultations, a new paragraph was added on tropical cyclones.

A3.6: Following huddle discussions, this new paragraph dealing with **tropical cyclones** was introduced. The paragraph proposed by the huddle was accepted without revision.

Observed Impacts on Ecosystems: A4: This subsection addresses impacts of cryosphere changes on terrestrial and freshwater species and ecosystems in high mountain and polar regions. In a headline sentence on observed impacts on ecosystems, reference to "disturbance regimes" was replaced with "ecological disturbances," as suggested by the UK.

Noting scant reference to the hydrological cycle throughout the SPM even though it is a major component of the ocean and cryosphere system, France proposed adding language on hydrological changes. The authors agreed to refer to "cryospheric and associated hydrological changes."

Germany noted negative impacts on many marine species and called for inserting references to "loss of biodiversity," but authors preferred keeping to a high-level statement in this case, given varied evidence. The headline statement was agreed.

A4.1-A4.3: The three paragraphs in this subsection, on increasing abundance of some plant and animal species, altered frequency and intensity of ecosystem disturbances, and plant productivity, were approved with minor amendments.

A5: This subsection addresses **shifts in geographical range and seasonal activities of marine species**. In response to Norway, the authors replaced reference to phenology with "seasonal activities." In response to Germany, the authors proposed adding reference to "oxygen loss to habitats" as an example of biogeochemical changes. Both of these changes were accepted.

Following lengthy discussions on a sentence on impacts on fished marine ecosystems and interactions between climate and fishing, and the impacts of these interactions on ecosystems, this sentence was sent to a huddle, facilitated by IPCC Vice-Chair Ko Barrett. The final sentence now refers to species in some marine ecosystems being impacted by effects of both fishing and climate change.

A5.1: This paragraph, which addresses **poleward shifts of species distributions**, was accepted without comment or revision.

A5.2: This paragraph deals with the **consequences of sea ice change and nutrient availability for marine ecosystems**. Germany requested a reference to the effects of changes in net primary production on biodiversity, and this was agreed.

A5.3: A paragraph on the **impacts of ocean acidification and oxygen loss on major upwelling systems** was accepted as presented.

A5.4: In a paragraph on **fisheries and catch potential**, a statement on ocean warming having "synergistic" interactions with overfishing for some fish stocks was changed to refer to its "compounding negative impacts from" overfishing.

Regarding a sentence referring to declines in abundance of fish and shellfish from global warming and biogeochemical changes, authors did not accept a suggestion by Saudi Arabia to add that the transfer of invasive species also contributes to declines. The paragraph was then accepted without further change.

A6: This subsection covers the **impacts on coastal ecosystems of multiple climate-related drivers**, including ocean warming, intensified marine heatwaves, acidification, loss of oxygen, salinity intrusion, and sea level rise. Regarding the headline statement, Germany questioned authors' replacement of coastal ecosystems as "under stress," which appeared in an earlier draft, with "affected," noting it represented a weaker formulation. The authors explained that impacts can be either positive or negative. The headline statement was approved as proposed.

A6.1: This paragraph covers **vegetated coastal ecosystems** such as mangroves, seagrass meadows, and kelp forests. The US, supported by the UK, Belgium, Australia, the EU, Mexico, and Chile, asked for clarity on carbon releases when wetlands are lost, i.e., whether they are driven by loss of carbon stocks or loss of sink capacity. Authors modified the text to clarify that it is "carbon stores" that are lost. India asked whether mentioning the range of estimated carbon releases was appropriate, given that it spans orders of magnitude, but the authors confirmed the figures.

The authors, at the request of the US, supported by the UK, Luxembourg, Belgium, Norway, the EU, and Mexico, reinstated previous text that describes drivers of coastal wetlands loss, including non-climate factors, and lists the benefits that wetlands provide in protecting coastlines from storms and erosion.

The US questioned reference to 36-43% losses of seagrass meadows and kelp forests following heatwaves that came from a single study. The text was revised to describe the effect, for which there is empirical support, but the specific figures were removed. With those revisions the paragraph was approved.

A6.2: This paragraph, which addresses **increased sea water intrusion, redistribution of species, and expansion of low oxygen areas**, was approved with minor modification.

A6.3: This paragraph deals with the **impact of sea level rise on coastal ecosystems**. In a sentence that compared the rate of GMSL rise to the rate of vertical growth of mangroves and marshes, the US asked whether the rate of GMSL used was the correct rate and authors confirmed that it was and specified this in the text. With that change the paragraph was accepted.

A6.4: A number of concerns were raised on this paragraph, which deals with **warm-water coral reefs and rocky shore ecosystems**. Norway, supported by Germany, lamented that the text lacks reference to "worldwide reef degradation," which had been in a previous draft. Authors reinstated this reference.

Grenada asked that observed coral bleaching be described as "unprecedented," but authors said the observational record was too short to permit such a description. Australia requested an indication of recovery time for reefs having experienced bleaching. The authors' suggestion to indicate a "slow" recovery time was unsatisfactory for many countries, who requested more specificity. Reference to "a 15-year timeframe" was then inserted. Following a question from Belgium, text was modified to also reflect potential irreversibility.

IPCC Vice-Chair Barrett suggested reference to acidification as a stressor, with impacts as great as if not greater than warming.

Canada and New Zealand asked for clarification on the meaning of “prolonged desiccation events,” with the authors explaining that these would occur at low tides. The group agreed to the huddle’s proposal to refer to prolonged periods of high temperatures and dehydration posing high risks to rocky shore ecosystems. The paragraph was agreed.

Figure SPM.2: Observed Regional Impacts from Changes in the Ocean and the Cryosphere: This figure was first taken up on Saturday morning. Various suggestions were made for clearer language, traceability, clarity on confidence levels, and references to specific regions or areas.

France, Spain, Morocco, Belgium, and Italy called for a column on the Mediterranean, and France and Switzerland called for separate reference to the European Alps. Sweden and Estonia proposed referencing marginal sea areas like the Baltic Sea.

Noting the very large number of people impacted, Bhutan, India, and China requested separate mention of risk to the Himalaya region.

Trinidad and Tobago, Haiti, and France objected to lack of reference to sargassum in tropical regions.

Tanzania, Ecuador, and Venezuela called for distinguishing whether the data was not assessed or not available. Indonesia suggested following IPCC guidelines for these cases.

Luxembourg, the Netherlands, and Belgium suggested changing the colors in the figure to refer to impacts instead of confidence levels, consistent with the approach used in other figures. Canada highlighted that confidence level relates to attribution and not to the trend, and called for making this clearer.

Revisions reflecting these concerns were presented on Sunday morning.

Saint Kitts and Nevis noted that the figure shows few entries with strong confidence, while the underlying report has very strong confidence statements. In response, authors explained that the issue is scale; confidence decreases from global to subregional scales.

On sargassum seaweed invasions, authors pointed to references in the underlying report, but confirmed that they were not part of the assessment for the figure, nor were impacts on tourism in the tropical western Pacific.

Responding to these revisions, France and Italy expressed disappointment with lack of coverage of the Mediterranean, with Italy calling for replacing the expression “marginal sea.”

Bhutan and India similarly lamented that the Hindu Kush Himalaya was subsumed under the High Mountain Asia category despite their differences and the potential for impacts on a huge number of people already highly vulnerable to climate change.

Saint Kitts and Nevis and Trinidad and Tobago deeply regretted that tourism and other sectors in their region were not assessed in spite of the dramatic impacts from cyclones and extreme weather events, with Trinidad and Tobago pleading for these to be assessed so they might better undertake adaptation in the region. They also called for a specific column showing the impact on human systems in SIDS.

Further revisions to this figure were presented on Monday morning. Authors described, *inter alia*, the addition of information on impacts on tourism for the Tropical Pacific and the Tropical Atlantic with reasonable levels of confidence, and of enhanced clarity on the figure’s labels.

The US, Chile, and El Salvador expressed concern with graphically presenting the effects on migration as positive or negative given the potential for misinterpretation. Bolivia suggested referring to ecosystem functions as well as services.

Discussion continued in a huddle and, following further adjustments in light of discussions, the figure was approved on Monday night.

Observed Impacts on People and Ecosystem Services: A7: This subsection addresses the **predominantly negative impacts of the shrinking cryosphere on food security, water quality, livelihoods, health and wellbeing, infrastructure, transportation, tourism, and recreation**, as well as culture of human societies, particularly for Indigenous peoples. On the headline statement on the cryosphere shrinking since the mid-20th century, following interventions from France and Chile, the group agreed to add “water resources” to a list of benefits negatively impacted by the shrinking cryosphere in the Arctic and high mountain areas, and approved the paragraph.

A7.1: Regarding a paragraph on **food and water security**, France and the US asked why reference to the western US was not included in a sentence on glacier retreat and snow cover changes contributing to localized declines in agricultural yields in some high mountain regions. Authors cited a lack of studies and low confidence for those impacts in the region.

In response to a request from India, the authors agreed to reference the “Hindu Kush Himalaya.” China preferred to keep a broader reference to the Himalayas, but authors responded that all research is on the Hindu Kush Himalaya. With this change, the paragraph was agreed.

A7.2: On this paragraph, which deals with the **negative impacts of cryosphere change on human health**, Canada noted that underlying studies on mental health impacts focus primarily on indigenous peoples and requested language reflecting this, to which the authors agreed. France, supported by Belgium and Morocco, asked for reference to the impacts of water “quantity” as well as quality, noting the health impacts of reduced glacial flow in dependent downstream communities. Authors noted insufficient research on this issue from a human health perspective. The paragraph was then approved.

A7.3: A paragraph on **adaptation undertaken by Arctic residents and institutions** was agreed as presented.

A7.4: On a paragraph on **summertime Arctic ship-based transportation**, the UK asked for an explanation of risks to Arctic marine ecosystems and coastal communities from shipping. Authors suggested, and the group agreed, to include the examples of invasive species and local pollution.

A7.5: A new paragraph on **increased exposure of people and infrastructure to natural hazards and links to changing cryosphere**, suggested by Switzerland, was inserted. The paragraph, which lists a number of specific high mountain regions where such links occur, was accepted as proposed.

A7.6: On a paragraph on **impacts on hydropower**, authors proposed, and the group agreed to, a sentence stating that changes in snow and glaciers have changed the amount and seasonality of runoff in snow-dominated and glacier-fed river basins. They also agreed to add reference to the impacts of decreased runoff on water resources, as suggested by France and Chile. With this, the paragraph was approved.

A7.7: This paragraph deals with **high mountain aesthetic and cultural aspects, and tourism and recreation**. Switzerland, supported by Bhutan, proposed two separate sentences, one covering aesthetic and cultural activities, with a list of impacted high mountain regions, and another covering commercial activities in high mountains, such as skiing, hiking, and mountaineering. Saudi Arabia, supported by China, objected to this separation. Following an explanation that such a distinction enables identification of different regions, the paragraph was approved with the two sentences.

A8: This subsection describes **impacts of changes in the ocean on marine ecosystems and ecosystem services**. With minor revisions for consistency, the headline statement was accepted.

A8.1: This paragraph addresses **impacts on spatial distribution and abundance of some fish and shellfish stocks**. Responding to a question from the US, the authors explained that if a broader group of organisms, such as corals, marine mammals, and seaweed, had been included, a high confidence level statement would not have been possible.

Regarding a sentence on negative consequence for Indigenous peoples, Saint Kitts and Nevis requested reference to local communities as well, which was agreed. The paragraph was approved with one other minor modification.

A8.2: This paragraph discusses **harmful algal blooms**. Grenada, supported by Saint Kitts and Nevis, asked to include reference to the impact of loss of coral reefs on peoples' cultural identity, suggesting insertion of text from the underlying document, and the UK suggested discussing waterborne pathogens such as *Vibrio*. The authors responded that projections on both of those subjects are taken up in Section B, but that there is not enough literature on observed present impacts to warrant inclusion in Section A. The paragraph was approved as proposed.

A9: This subsection addresses **risks for human communities in low-lying coastal areas**. Regarding a sentence in the headline statement on exposure of coastal communities to multiple climate-related hazards, Saint Kitts and Nevis asked for, and authors agreed, to include reference to tropical cyclones among key hazards. With this change the headline statement was agreed.

A9.1: A paragraph on **attribution of coastal impacts** was approved as presented.

A9.2: On **coastal protection measures, advance, and retreat**, in a sentence linking to Figure SPM.5 on sea level rise risk and responses, a proposal from Saint Kitts and Nevis to refer to the effectiveness of "responses" to sea level rise instead of "adaptation" was accepted and the paragraph was approved.

Final SPM Text: Section A addresses observed changes and impacts.

Subsection A1 addresses the **widespread shrinking of the cryosphere in response to global warming**, and observes that:

- ice sheets and glaciers worldwide have lost mass;
- Arctic June snow cover extent on land has shrunk by approximately 2.5 million km² since 1997;
- permafrost temperatures have increased to record high levels, which is a concern since permafrost contains almost twice the carbon contained in the atmosphere; and
- since 1979, Arctic sea ice extent has *very likely* decreased for all months of the year relative to previous years.

Subsection A1 also contains **Figure SPM.1**, which shows past changes in GMSL, sea-surface and surface air temperature, surface ocean pH, extent of Arctic sea ice and snow cover, permafrost area, ocean heat content, and ice sheet mass losses. It also shows future trends for those variables under RCP2.6 and RCP8.5.

Box SPM.1 explains the use of RCP scenarios in the IPCC's work and shows the likely temperature increases associated with each, noting that this report uses mostly a comparison of a high mitigation scenario (RCP2.6) and a no mitigation scenario (RCP8.5) to illustrate the range of possible futures.

Subsection A2 addresses **global ocean warming**, and stresses that:

- since 1970 the ocean has taken up more than 90% of the excess heat in the atmosphere;

- the rate of uptake has more than doubled since 1993, driven by anthropogenic forcing;
- even the deep ocean below 2 km has warmed, especially in the Southern Ocean;
- since 1982 marine heatwaves have doubled in frequency, and become longer, more intense, and more extensive;
- surface warming and increased fresh meltwater are inhibiting the natural mixing of surface and deeper ocean waters;
- the ocean has taken up 20-30% of anthropogenic CO₂ emissions since the 1980s, leading to significant acidification;
- the upper ocean has lost up to 3.3% of its oxygen between 1970 and 2010, likely expanding oxygen minimum zones by 3-8%; and
- there is evidence that the AMOC has weakened relative to 1900, but there is not enough evidence to attribute this to anthropogenic forcing.

Subsection A3 addresses **GMSL rise**, and notes:

- the rate of GMSL rise for 2006–2015 of 3.6 mm per year is unprecedented over the last century, and since 1970 is primarily due to anthropogenic forcing;
- loss of mass from the Antarctic Ice Sheet tripled in the decade 2007-2016 relative to the previous decade, and doubled for the Greenland Ice Sheet;
- acceleration in the Antarctic alone has the potential to lead to sea level rise of several meters in a few centuries;
- extreme wave heights, which contribute to extreme sea level events, coastal erosion, and flooding, have increased in the Southern Atlantic Ocean by around 1.0 cm per year since 1985; and
- anthropogenic climate change has increased precipitation, winds, and extreme sea level events associated with some tropical cyclones.

Subsection A4 addresses the **impacts of melting ice, retreating snow, and thawing permafrost on flora and fauna in high mountain and polar regions**, and stresses:

- species of plants and animals in high mountains and polar regions have been impacted, with some expanding their range and others facing risk of extinction; and
- plant productivity has increased overall across the tundra and decreased in the boreal forest.

Subsection A5 addresses **impacts on marine species**, and observes that:

- marine species since the 1950s have *very likely* shifted their ranges toward the poles by between 29-52 km per decade, with impacts on ecosystem structure and function;
- Arctic spring phytoplankton blooms are occurring earlier and increasing in ice-free waters;
- loss of polar sea ice is shrinking habitat for dependent sea mammals and birds, and impacting their foraging success and prey distribution;
- loss of oxygen and increasing acidification have negatively impacted biomass production and species composition in two of the ocean's most productive upwelling systems: the California Current and the Humboldt Current; and
- ocean warming has contributed to an overall decrease in maximum catch potential, compounding the impacts from overfishing.

Subsection A6 addresses **impacts on coastal ecosystems of multiple climate-related drivers**, including ocean warming, intensified marine heatwaves, acidification, loss of oxygen, salinity intrusion, and sea level rise. It notes that:

- loss of seagrass meadows, kelp forests, and mangroves is responsible for significant CO₂ emissions, and reduces coastal protection from storms;

- ocean warming has exacerbated the effects of human development, leading to the expansion of low-oxygen ocean areas (so-called “dead zones”);
- sea level rise has meant loss of biodiversity and ecosystem functionality in coastal ecosystems, with marshes and mangroves often migrating inland; and
- marine heatwaves have resulted in large-scale coral bleaching events at increasing frequency, causing worldwide reef degradation since 1997.

Subsection A6 also contains **Figure SPM 2**, which shows observed impacts from changes in the ocean and cryosphere, broken down by region.

Subsection A7 addresses the **impacts of the shrinking cryosphere on local populations, particularly Indigenous peoples**, and underlines that:

- herding, hunting, fishing, and gathering have been disrupted, with negative impacts on food and water security, livelihoods and cultural identity of Arctic residents;
- glacier retreat and snow cover changes have contributed to localized declines in agricultural yields in high mountain regions, including the Hindu Kush Himalaya and the tropical Andes;
- in the Arctic, impacts have included increased risk of food- and waterborne diseases, malnutrition, injury, and mental health challenges, especially among Indigenous peoples;
- in some high-mountain areas, water has been contaminated by mercury released from melting glaciers and thawing permafrost;
- Arctic residents and industries have started to adapt timing of their activities and address climate-related infrastructure failure, despite multiple challenges;
- increased ship transport in the ice-free Arctic increases local pollution and the risk of invasive species for Arctic ecosystems and coastal communities;
- altered timing and volume of snow and glacier melt have impacted major river basins, including by affecting hydropower facilities; and
- glacier and snow decline in high mountain regions has hurt tourism and recreation sectors, and has negative aesthetic and cultural impacts.

Subsection A8 addresses **impacts of ocean changes on marine ecosystems and ecosystem services**, and states that:

- warming-induced changes in species distribution and abundance have negatively impacted fisheries-dependent Indigenous peoples and local communities;
- those changes have also challenged international governance regimes that are charged with regulating fishing to ensure ecosystem integrity and the sharing of fisheries resources; and
- climate-related drivers have contributed to increased range and frequency of harmful algal blooms in coastal areas since the 1980s, with negative effects on food security, tourism, local economy, and human health.

Subsection A9 addresses the **multiple climate-related hazards to which coastal communities are exposed**, and notes that:

- hazards include tropical cyclones, extreme sea levels and flooding, marine heatwaves, sea ice loss, and permafrost thaw;
- climate change is one of many drivers of those hazards; others include groundwater extraction, pollution, habitat degradation, and reef and sand mining;
- coastal protection increasingly uses a combination of built infrastructure and working ecosystems; and

- adaptive inland movement of coastal peoples has been observed, but is generally restricted to small human communities.

B: Projected Changes and Risks

This section addresses projected physical changes, projected risks for ecosystems, and projected risks for people and ecosystem services. A footnote was inserted at the beginning of this section, at the request of Ecuador, Tanzania, and India, explaining why the report focused almost exclusively on the RCP2.5 and RCP8.6 emissions scenarios. Following huddle discussions to craft text, the footnote was approved.

Projected physical changes: B1: This subsection addresses **projected glacier mass loss, permafrost thaw, and decline in snow cover and Arctic sea ice extent**. Delegates discussed whether “ambitious” reductions in GHG emissions should be mentioned, and how and whether the headline statement should reflect a new sentence on ice sheet change specifically. Following informal discussions, the headline statement was agreed with this addition.

B1.1: A paragraph on **projected glacier mass reductions and corresponding sea level contributions** was approved as presented.

B1.2: At Germany’s suggestion, a new paragraph was added by authors, **comparing the Greenland Ice Sheet’s projected contribution to sea-level rise to that of the Antarctic Ice Sheet**. It notes that while the contribution to sea level rise of Greenland’s Ice Sheet is currently larger, Antarctica could become a larger contributor by 2100 as a consequence of rapid Antarctic Ice Sheet retreat. It also provides projected figures under RCP2.6 and RCP8.5. Following minor modifications, the paragraph was approved.

B1.3: A paragraph on **projected decreases in Arctic autumn and spring snow cover** was approved with a minor editorial change.

B1.4: On a paragraph on **widespread permafrost thaw**, Canada suggested adding a confidence statement regarding the magnitude of the projected changes in permafrost thaw this century.

Regarding a sentence on the release of CO₂ and methane from permafrost thaw, the Friends World Committee for Consultation proposed language to reflect that the release of 10s to 100s of billions of tons of permafrost carbon has the potential to “significantly” exacerbate climate change. Saudi Arabia sought text to make clear that such a massive release is only foreseen with RCP8.5. India expressed concern that the reference to smaller projected releases for low emissions scenarios might imply that “polluting a little is acceptable.” These issues were addressed by authors.

On Monday, authors presented their proposed changes, which limited discussion of methane to its mention as being released to the atmosphere under RCP8.5, and specified that lower emissions scenarios slow the release of carbon emissions from the permafrost region. Authors also proposed a new footnote on annual CO₂ emissions from fossil fuel and land use change from 2007-2017. Saudi Arabia objected to mentioning land use and requested specific figures on methane emissions. Following a further huddle discussion and comments by Saudi Arabia and the Netherlands, the footnote, as agreed, does not include reference to fossil fuel and land use, and instead specifies average annual anthropogenic methane emissions between 2003 and 2012, along with specific figures for annual CO₂ emissions between 2007 and 2017.

B1.5: A paragraph on **mountain hazards** was agreed as presented.

B1.6: In a paragraph on **river runoff in high mountain basins**, France and India suggested specifying the European Alps and Pyrenees and the Himalayas, respectively, in a list of examples. An author replied that very few, if any, studies have been undertaken on regions other than the Andes and European Alps.

Following a huddle, facilitated by WG I Vice-Chair Carolina Vera, a new sentence was approved stating that projected declines in glacier runoff by 2100 under RCP8.5 can reduce basin runoff by 10% or more in at least one month of the melt season in several large river basins, especially in High Mountain Asia during the dry season.

B1.7: On a paragraph on **differences in projected Arctic sea ice loss from 2050**, France requested addition of information for warming levels above 2°C. Several delegates questioned references only to losses from 2050 onward. In response, following informal consultations, authors presented revised text specifying that Arctic sea ice loss is projected to continue through mid-century. With another small change, the paragraph was agreed.

B2: This subsection deals with the **transition of the ocean to unprecedented ocean conditions**, such as stratification, acidification, and frequent El Niño events. The authors suggested adding reference to La Niña events and carbon export to the headline statement, to reflect recent changes in the subparagraphs. Saudi Arabia questioned whether all the conditions were in fact “unprecedented,” and the authors withdrew the reference to carbon export, noting it did not merit the label. With those changes the text was approved.

B2.1: A paragraph on **ocean warming** was agreed following France’s proposal for reference to carbon penetration in a sentence on annual mean density ocean stratification projections inhibiting vertical nutrient and oxygen fluxes.

B2.2: A paragraph on **ocean oxygen content** was approved following the acceptance of France’s request to reference the decrease of carbon export to the ocean.

B2.3: Regarding a paragraph on **open ocean surface pH**, many opined concerns that the language used was too technical for policymakers. With modifications to increase readability, and reversion to text from the previous draft SPM, on the virtual certainty that continued carbon uptake by the ocean to 2100 will exacerbate ocean acidification, the paragraph was approved.

B2.4: This paragraph deals with the **combined emergence of ocean acidification, warming, and oxygen loss as risks for open ocean ecosystems**. The US questioned whether the three drivers referred to in this paragraph will affect “over 60%” of the surface ocean under RCP8.5, noting that this statistic in the underlying report also depends on net primary production and nitrate content. Following huddle discussions, authors proposed text reflecting that all five drivers are implicated in marine ecosystem change and the amended paragraph was approved.

B2.5: On a paragraph on **marine heatwaves**, increase in “magnitude” was replaced with increase in “intensity,” after comments by Trinidad and Tobago, Portugal, and the US. A new sentence was also added, stating that marine heatwaves will further increase in frequency, duration, spatial extent, and intensity under global warming.

B2.6: A paragraph on **projected increases in the frequency and intensity of extreme events**, which only mentioned El Niño in the previous draft, was revised to include reference to La Niña events as well, as suggested by Spain, Tanzania, Chile,

Zimbabwe, Kenya, Nicaragua and others. Kenya, Zimbabwe, and others also called for including reference to the Indian Ocean Dipole, to which authors agreed.

Following additional revisions by authors, a new text was presented, which included projections for extreme La Niña events and additional language on the Indian Ocean Dipole driving climate variability in the region. After lengthy discussion on projections of extreme El Niño events occurring about twice as often under both RCP scenarios in the 21st century as in the 20th century, the sentence was retained, and the paragraph agreed.

B2.7: A paragraph on **projected weakening of AMOC** engendered some discussion, including requests for explanation of “any substantial” weakening of AMOC. After a huddle with authors, and based on a proposal by Belgium, a sentence was added noting that such changes would be in addition to the global warming signal. Following the insertion of additional confidence statements, the paragraph was agreed.

B3: A subsection on **projected sea level rise and extreme sea level events** was first addressed in plenary and then in a contact group, which also addressed Figure SPM.4 on extreme sea level events. Noting that some of the information was new since AR5 and highlighting its policy relevance, many countries, including Norway, the UK, Australia, Ireland, Belize, and others, called for clarity in the text on the differences between the RCP2.6 and RCP8.5 scenarios and discussion of sea level rise beyond 2100.

The US called for reference to exposure to sea level rise and extreme events in the text and in related SROCC figures.

Saudi Arabia reiterated her call for mid-range scenarios. She also questioned references to mitigation, saying the SROCC was a WG I and II report, and asked for clarification of the term “human-induced subsidence.”

Discussion on all paragraphs in this subsection continued in a contact group.

The headline statement for this subsection was agreed without any further significant change.

B3.1: This paragraph on **projected GMSL rise under RCP2.6 and RCP8.5** was approved following a revised text based on contact group discussions.

B3.2: This paragraph, on **regional variations in projected GMSL**, was agreed without revision, following contact group discussions.

B3.3: This paragraph deals with the **rate of GMSL rise**. Following the presentation of text revised in the contact group and in response to Australia, the authors changed a reference to the West Antarctic Ice Sheet as a cause for concern, referring instead to “parts of the Antarctic Ice Sheet,” and the amended paragraph was agreed.

B3.4: A paragraph on **the impacts of GMSL rise on the frequency of extreme sea level events** was modified by the contact group to include language on the projected frequency of historical centennial events under the RCP8.5, RCP4.5 and RCP2.6 scenarios. The paragraph was then agreed as presented.

B3.5: This paragraph on **wave heights, coastal tidal amplitudes and patterns, and coastal hazards** was modified by the contact group, with text on tropical cyclones and coastal hazards moved to a new paragraph.

B3.6: A new paragraph, on the **exacerbation of coastal hazards from tropical cyclones and from increased intensity and magnitude of storm surges** was approved as presented following contact group discussions.

Projected Risks for Ecosystems: B4: This section deals with **species and wildfire impacts of land cryosphere changes in high mountains and polar regions**. The headline statement was agreed with only minor changes to the text for greater consistency with the rest of the subsection.

B4.1-B4.3: Accepted with no comment or minor amendment were paragraphs on: population declines of many alpine species in high-mountain regions; projections of loss of globally unique biodiversity on Arctic land; and impacts of permafrost thaw and decrease in snow on Arctic and mountain hydrology and wildfires.

B5: This subsection addresses **marine animal communities, their production, and fisheries catch potential**. Regarding the headline statement, Germany requested reference to the eventual loss of biodiversity, but authors said they could not draw that conclusion from the literature. Following a modification for enhanced clarity, the paragraph was approved.

B5.1: A paragraph dealing with **impacts on the biomass, production, and community structure of marine ecosystems** was approved without revision.

B5.2: On a paragraph discussing the **impacts of enhanced stratification and reduced nutrient supply**, Spain asked whether nutrient supply from melting glaciers might also be mentioned. Authors responded that this was an important dynamic but that the literature was too thin to provide a basis for its inclusion, and the text was approved without revision.

B5.3: This paragraph, on the **impacts of warming, acidification, reduced seasonal sea ice extent, and loss of multi-year sea ice on polar marine ecosystems**, such as birds, fish, and marine mammals, was accepted without discussion or revision.

B5.4: This paragraph discusses **impacts on cold water corals of ocean warming, oxygen loss, acidification, and a decrease in flux of organic carbon** from the surface to the deep ocean. Norway suggested also discussing the impacts of ocean acidification, but the authors noted that while there was evidence in the literature on impacts for warm water corals, there was none for cold water corals. The paragraph was accepted as presented.

Figure SPM.3: Projected Changes, Impacts and Risks for Ocean Ecosystems as a Result of Climate Change: This figure was addressed in plenary on Tuesday. Authors introduced a revised figure based on comments made by delegates. Authors noted, *inter alia*: the request by Germany, the US, the Russian Federation, and Canada to strengthen traceability of methods for the “burning embers” diagram and to include a link to earlier SRs; efforts to increase the readability of maps and contrast of shading; clarification of the time frame of risk assessment in the burning embers diagram; and the use of confidence levels and uncertainty language.

Following huddle discussions, and further modifications and corrections to further improve the figure, it was agreed.

B6: This subsection addresses **projected risks of severe impacts on biodiversity, structure, and function of coastal ecosystems**. After some discussion and clarifications, a reference to risks for sensitive ecosystems, such as seagrass meadows and kelp forests, at 1.5°C was changed to 2°C given that, in accordance with Figure SPM.3, the calculation is now based on global surface air temperature, not sea surface temperature.

Saudi Arabia, opposed by Saint Kitts and Nevis, France, Norway, Fiji, Belgium, Australia, Mexico, and others, proposed deleting a sentence stating that warm water corals are projected to experience very high risk even below global warming of 1.5°C,

saying it was redundant and questioning its consistency with the underlying report. Authors preferred maintaining the sentence as written given its very high confidence level and specificity.

After further discussions in a huddle, the sentence was agreed.

B6.1: In a paragraph on **projected risk levels for coastal ecosystems**, authors proposed deleting a sentence on risks to seagrass meadows, kelp forests, and coral reefs even at 1.5°C of warming, since similar language had been moved to the headline statement. The amended paragraph was agreed.

B6.2: In response to a suggestion by Germany in this paragraph on **risks of losses of coastal vegetation and associated carbon stores**, authors added text to indicate that risks would increase with further warming. The amended text was agreed.

B6.3: This paragraph deals with **risks to biota of expanded salinization and hypoxia in shallow estuaries**. Luxembourg expressed concern that the two sentences in the paragraph seemed to contradict each other on differences between low- and high-emissions scenarios. The paragraph was amended to remove any reference to conflicting scenarios and the paragraph was agreed.

B6.4: In a paragraph stating that **almost all warm-water coral reefs are projected to suffer significant losses of area and local extinctions even if global warming remains below 1.5 C**, Saudi Arabia asked why the current text predicted significant losses of area and local extinctions even if global warming remains below 1.5°C, when the previous text said 2°C. The authors attributed this to an error in the underlying report. Saudi Arabia cited the underlying report to argue that “below 1.5°C” was incorrect, and in response the authors cited the text’s prediction of damage to coral reefs “even if global warming is limited to 1.5°C.” Following informal consultations, the paragraph was agreed as presented.

Projected Risks for People and Ecosystem Services: B7: This subsection addresses **projected impacts on water resources and their uses and increased risk for infrastructure, cultural, tourism, and recreational assets**. The headline statement was approved as presented.

B7.1: On a paragraph that addresses **risks to human settlements and livelihood options in high mountain areas and the Arctic**, following a request from Switzerland, a new sentence was added to reflect that significant risk reduction and adaptation strategies help to avoid increased impacts from mountain flood and landslide hazards. The paragraph was agreed with this addition.

B7.2-B7.3: Paragraphs on impacts of permafrost thaw on infrastructure in the Arctic and high mountain areas and on high mountain tourism, recreation, and cultural assets were agreed as presented.

B8: This subsection addresses impacts of **future shifts in fish distribution, abundance, and catch potential on marine dependent communities**. The headline statement was approved without comment.

B8.1: A paragraph on **projected geographical shifts and decreases of global marine animal biomass and fish catch potential** under RCP8.5 relative to RCP2.6 was approved as presented.

B8.2: On a paragraph on **projected decline in coral reefs**, “warm water” coral reefs were specified in response to a query from Norway. In response to Saudi Arabia, a reference to SRCCL was deleted from the line of sight (list of citations) for this paragraph.

B8.3: On global warming compromising seafood safety, authors did not agree to Spain's proposal to specify cholera as a heightened risk or Estonia's request to refer to a poleward expansion of *Vibrio* pathogens. The paragraph was approved with no change.

B8.4: A paragraph on key cultural dimensions of lives and livelihoods at risk from impacts on marine ecosystems and their services was approved as presented.

B9: This subsection addresses **risks for human communities in low-lying coastal areas**, and ambitious adaptation, including transformative governance that is expected to reduce that risk. The headline statement was agreed as presented.

B9.1: This paragraph addresses **risks related to sea level rise and associated extreme events**. Fiji, supported by Saint Kitts and Nevis, called for reference to tropical cyclones. Authors agreed to the insertion.

Saint Kitts and Nevis also asked for including mention of land loss, which was eventually agreed.

These sentences, along with others on adaptation limits in a subsequent paragraph, were taken up together in a huddle and eventually agreed as presented by the group.

B9.2: This paragraph addresses **risks for vulnerable communities in coral reef environments, urban atoll islands, and low-lying Arctic locations** from sea level rise. Australia and the US questioned what type of limits were meant regarding a reference to adaptation limits. Authors explained that it covered the full range of adaptation limits and therefore the generic reference was appropriate. The sentence was taken up in a huddle with sentences from the previous paragraph and agreed as presented by the group without further comments.

B9.3: This paragraph addresses **greater adaptation opportunities provided by a slower rate of climate-related ocean and cryosphere change**. Belize proposed a sentence to reflect that while investments are generally cost-efficient for densely populated urban areas, rural and poorer areas will be challenged to afford such adaptation investments with annual costs for some small island states amounting to several percent of gross domestic product (GDP). This sentence was forwarded to a huddle and eventually agreed as revised in the huddle without further comments.

Figure SPM.4: Extreme Sea Level Events: Venezuela, supported by Nigeria, Ecuador, and Brazil, asked whether blank spaces for many coastlines in the figure, including large parts of Africa and Latin America, indicated lack of data, or no impacts based on an assessment of existing data. Canada requested that the panel on historical centennial events be modified to indicate locations where such events would be less likely due to vertical land movements. Saudi Arabia asked for confidence levels for the panel indicating locations where these events are projected to become annual more than 10 years earlier under RCP8.5 compared to RCP2.6 and objected to the presentation of only these two scenarios.

A huddle produced a number of revisions, including a new category of locations in the panel on scenario differences, regarding historical centennial events that will experience no sea level rise before 2100. The authors explained that they did not accommodate the request to include RCP4.5 in the graphic because in many cases the difference between RCP2.6 and RCP8.5 was insignificant and RCP 4.5 results would have added almost no new information. The revised graphic was approved without further changes.

The revised caption for the figure included: additional text to clarify that blank areas do not indicate absence of impacts, but rather absence of data; and a reference to RCP4.5 data available

in Chapter 4 of the underlying report on Sea Level Rise and Implications for Low Lying Islands, Coasts, and Communities. The caption was approved with only minor editorial changes.

Final SPM Text: Section B addresses projected physical changes, projected impacts on ecosystems, and projected impacts on people and ecosystems.

Subsection B1 addresses **global-scale glacier mass loss, permafrost thaw, and decline in snow cover and Arctic sea ice extent in the near term** and stresses:

- ranges of projected glacier mass reductions and loss between 2015 and 2100;
- regions with mostly smaller glaciers are projected to lose more than 80% of their current ice mass by 2100 under RCP8.5, and many glaciers are projected to disappear regardless of future emissions;
- by 2100, the Greenland Ice Sheet is projected to contribute 7 cm (RCP2.6) to 15 cm (RCP8.5) to GMSL rise and the Antarctic Ice Sheet will contribute 4 cm (RCP2.6) to 12 cm (RCP8.5);
- relative to 1986-2005, Arctic autumn and spring snow cover are projected to decrease 5-10% in the near term under RCP2.6 and by an additional 15-15% by 2100 under RCP8.5;
- widespread projected permafrost thaw for this century and beyond under both RCP2.6 and RCP8.5;
- projected glacier retreat and permafrost thaw for high mountain areas, decreasing the stability of slopes and increasing the number of glacier lakes and floods, landslides, and snow avalanches;
- in all emissions scenarios, glacial runoff is projected to peak at or before 2100 and has already peaked in regions with little glacier cover such as the tropical Andes and the Alps;
- projected changes in river runoff in snow-dominated or glacier-fed high mountain basins; and
- projected Arctic sea ice loss continuing through 2050, with differences thereafter depending on the magnitude of global warming.

Subsection B2 addresses the projected **transition of the ocean to unprecedented conditions**. It underscores that:

- the ocean will continue to warm throughout the 21st century, with the top 2000 meters projected to take up 5-7 times more heat under RCP8.5, or 2-4 times more under RCP2.6, than the observed accumulated ocean heat uptake since 1970;
- ocean oxygen content, upper ocean nitrate, net primary production, and carbon export are projected to decline globally by 2081-2100 relative to 2006-2015;
- ocean acidification will be exacerbated by continued carbon uptake by the ocean by 2100;
- risks to open ocean ecosystems are elevating, due to unprecedented climate conditions that are currently developing;
- relative to 1850-1900, marine heatwaves by 2100 are projected to increase in frequency by 50 times under RCP8.5 and 20 times under RCP2.6, while intensity is projected to increase by 10 times under RCP8.5;
- extreme El Niño and La Niña events are projected to likely double in frequency in the 21st century and intensify existing hazards; and
- the AMOC is projected to weaken in the 21st century under all RCPs, although collapse is *very unlikely*.

Subsection B3, on an **increasing rate of continuing sea level rise and more frequent extreme sea level events**, stresses that:

- GMSL rise is projected for the period 2081-2100 under both RCP2.6 and RCP8.5 and are higher than projections in AR5, due to larger projected ice loss from the Antarctic Ice Sheet;

- sea level projections show regional differences around GMSL, with important differences driven by non-climate related processes;
- the rate of GMSL is projected to reach 15 mm per year under RCP8.5 in 2100 and several centimeters per year after that, with sea level rise possibly increasing to substantially higher values if Antarctica's ice shelf loss and ice sheet instabilities increase Antarctica's contribution to sea level rise;
- GMSL rise will cause the frequency of extreme sea level events at most locations to increase, with local sea levels that historically occurred one per century projected to become annual events by 2100 under all scenarios;
- significant wave heights are projected to increase in some areas and decrease in others, with changes in tidal amplitudes and patterns due to sea level rise and coastal adaptation measures enhancing or ameliorating coastal hazards locally; and
- coastal hazards will be exacerbated by an increase in the average intensity and magnitude of storm surge, and precipitation rates of tropical cyclones.

Subsection B4 covers **projected risks for terrestrial and freshwater ecosystems** from future land cryosphere changes. It underscores that:

- further upslope migration by lower-elevation species, range contractions and increased mortality will lead to population declines of many alpine species in high-mountain regions;
- a loss of globally unique biodiversity is projected on Arctic land as limited refugia exist for some High-Arctic species;
- permafrost thaw and decrease in snow will affect Arctic and mountain hydrology and wildfire, with impacts on vegetation and wildlife; and
- wildfire is expected to increase for the rest of this century across most tundra and boreal regions, and in some mountain regions.

Subsection B5 addresses **decrease in global biomass of marine animal communities, their production, and fisheries catch potential**, and shift in species composition over the 21st century. It highlights that:

- projected ocean warming and changes in net primary production alter biomass, production, and community structure of marine ecosystems and maximum catch potential of fisheries by 2100;
- under enhanced stratification, reduced nutrient supply is projected to cause tropical ocean net primary production to decline by up to 16% by 2100, warming and sea ice changes are projected to cause marine net primary production in the Arctic and around Antarctica to increase, and, globally, the sinking flux of organic matter from the upper ocean is projected to decrease;
- warming, ocean acidification, reduced seasonal sea ice extent, and continued loss of multi-year sea ice are projected to impact polar marine ecosystems through direct and indirect effects on habitats, populations, and their viability; and
- ocean warming, oxygen loss, acidification, and a decrease in flux of organic carbon from the surface to the deep ocean are projected to harm habitat-forming cold-water corals.

Subsection B5 also contains **Figure SPM.3**, showing projected changes, impacts and risks for ocean ecosystems as a result of climate change.

Subsection B6 addresses **risks of severe impacts on biodiversity, structure and function of coastal ecosystems under elevated temperatures under high emissions scenarios**. It states that:

- all coastal ecosystems assessed are projected to face increasing risk level;

- coastal vegetation and associated carbon stores are at moderate risk at 1.5°C global warming and increase with further warming, with 20-90% of coastal wetlands projected to be lost by 2100;
- ocean warming, sea level rise, and tidal changes are projected to expand salinization and hypoxia in estuaries, with high risks for some biota; and
- almost all warm water coral reefs are projected to suffer significant losses of area and local extinctions even if global warming is limited to 1.5°C.

Subsection B7 discusses future **cryosphere changes on land**, which are projected to affect water resources and their uses. It underscores that:

- disaster risks to human settlements and livelihood options in high mountain areas and the Arctic are expected to increase due to future changes in hazards such as floods, fires, landslides, avalanches, unreliable ice and snow conditions, and increased exposure of people and infrastructure;
- permafrost thaw-induced subsidence of the land surface is projected to impact urban and rural communication and transportation infrastructure in the Arctic and high mountain areas; and
- high mountain tourism, recreation and cultural assets are projected to be negatively affected by future cryospheric changes.

Subsection B8 covers **effects on income, livelihoods, and food security of marine resource-dependent communities** due to future shifts in fish distribution and decreases in their abundance and fisheries catch potential. It states that:

- projected geographical shifts and decreases of global marine animal biomass and fish catch potential are more pronounced under RCP8.5 relative to RCP2.6, elevating the risk for income and livelihoods of dependent human communities;
- the decline in warm water coral reefs is projected to greatly compromise the services they provide to society, including food provision and security, coastal protection, and tourism;
- global warming compromises seafood safety through human exposure to elevated bioaccumulation of persistent organic pollutants and mercury in marine plants and animals, increasing prevalence of waterborne *Vibrio* pathogens and heightened likelihood of harmful algal blooms; and
- climate change impacts on marine ecosystems and their services put key cultural dimensions of lives and livelihoods at risk, including the role of potentially rapid and irreversible loss of culture and local and indigenous knowledge.

Subsection B9 underscores that **increased mean and extreme sea level rise, ocean warming, and acidification are projected to exacerbate risks for human communities in low-lying coastal areas**. It stresses that:

- risks due to mean sea level rise and extreme events are projected to significantly increase through this century under all GHG emissions scenarios in the absence of more ambitious adaptation efforts, under current trends, with annual coastal flood damages projected to increase by 2-3 order of magnitude by 2100;
- high to very high risks from sea level rise are approached for vulnerable communities in coral reef environments, urban atoll islands, and low-lying Arctic locations well before 2100 under high emissions scenarios with some island nations likely to become uninhabitable;
- globally, a slower rate of climate-related ocean and cryosphere change provides greater adaptation opportunities, but while ambitious adaptation, including governance for transformative

change, has the potential to reduce risks in many locations, such benefits can vary between locations; and

- at a global scale, coastal protection can reduce flood risk by 2-3 orders of magnitude during the 21st century, depending on investments in the order of several hundreds of billions of USD, levels that would be challenging for many countries.

C: Implementing Responses to Ocean and Cryosphere Change

This section addresses challenges, strengthening response options, and enabling conditions.

Challenges: C1: This subsection addresses increasing challenges to current governance efforts to develop and implement adaptation responses. The headline statement was agreed without change.

C1.1: A paragraph describing **temporal scales of climate impacts relative to those of governance** immediately became conflictual, with delegations expressing different opinions on use of the term “governance.” Saudi Arabia, with Switzerland, argued for its deletion, believing it to be policy prescriptive, while the US, supported by Trinidad and Tobago, cautioned that in other UN languages it might be translated as “government.” However, other countries cited use of the term in other IPCC reports.

WG II Co-Chair Pörtner proposed that a contact group, facilitated by IPCC Vice-Chair Sokona, further discuss this paragraph. Saudi Arabia strongly objected to sending text not yet discussed in detail in plenary to a contact group. Following protracted discussion, the contact group convened, following which governance “systems” was replaced with “arrangements,” with authors reporting new text stating that time horizons of temporal scales of impacts are longer than those of governance arrangements, such as planning cycles, public and corporate decision-making cycles, and financial instruments. The paragraph was agreed as revised.

C1.2: On this paragraph, which discusses the **limitations of current governance arrangements**, authors suggested replacing the reference to governance “systems” with “arrangements,” as in the previous paragraph. Saudi Arabia asked that agreed examples of types of governance systems also be included in this paragraph, but the authors pointed out that those were not appropriate in the current context, and offered instead: “marine protected areas, spatial plans and water management regimes.” India and Trinidad and Tobago asked for reference to governance difficulties faced in high mountains and SIDS, respectively. The authors proposed text referencing SIDS and adding “inaccessibility” to the list of challenges facing governance systems. With these revisions the paragraph was agreed.

C1.3: This paragraph, addressing **barriers and limitations to adaptation in ecosystems**, was added at the request of Grenada, and consists of text taken directly from Chapter 5 of the underlying report (Changing Ocean, Marine Ecosystems, and Dependent Communities). The paragraph was approved as presented.

C1.4: This paragraph deals with **financial, technological, institutional, and other barriers to effective adaptation**. Grenada asked whether the paragraph could include reference to barriers and limitations to ecosystem adaptation, and the authors suggested adding a new paragraph devoted to this. The US noted that adaptation limits is not a static concept, but is highly context specific, and, supported by Australia, asked for the text to reflect this. The text was sent to a huddle, which resulted in revised text noting that the potential for barriers to act as adaptation limits depends on context-specific circumstances. With those revisions the paragraph was agreed.

Strengthening Response Options: C2: This subsection addresses **support for services and options provided by ocean and cryosphere-related ecosystems**. On the headline statement on ocean protection, restoration, and precautionary ecosystem-based management, Saudi Arabia opposed text stating that ecosystem-based adaptation will only be effective if global warming is limited to 1.5°C. Estonia suggested referring to “the lowest levels of warming” instead of “global warming limited to 1.5°C.” With this change, the paragraph was approved.

C2.1: This paragraph describes **how networks of protected areas help maintain ecosystem services**, including by allowing species’ ranges to shift within ecosystems. India, supported by Chile, asked why the Antarctic Treaty, as a premier example of an internationally protected area, was not cited while the Arctic was. Authors cited a lack of literature on the Treaty’s role in maintaining ecosystem services and proposed replacing the specific reference to Arctic with a broader reference to “polar land regions.” With this amendment, the paragraph was accepted.

C2.2: This paragraph addresses **actions that can be locally effective in enhancing ecosystem-based adaptation**, including terrestrial and marine habitat restoration, and ecosystem management tools, such as assisted species migration and coral gardening. In a sentence highlighting reasons for the success of such actions, Saudi Arabia insisted on maintaining reference to low emissions scenarios, rather than to limiting global warming to 1.5°C. Authors responded that some actions, including coral gardening, are ineffective if temperatures rise above 1.5°C, noting, for example, the sensitivity of corals to higher temperatures, and said that governments had directed them to be as specific as possible.

Many countries, including Fiji, Saint Kitts and Nevis, Grenada, France, Chile, Luxembourg, the UK, the Maldives, Belize, New Zealand, Germany, Canada, Mexico, and Cuba, supported reference to 1.5°C, with Belize warning that almost all coral reefs will degrade from their current state even if temperature rise is limited to 2°C.

Authors suggested adding SR15 to the line of sight, noting its coverage of coral reefs. Saudi Arabia opposed citing other SRs, while New Zealand and others supported the citation. Saudi Arabia said if SR15 is cited, then it must be qualified with references to all the knowledge gaps in SR15. Questions regarding the procedure for citing other IPCC reports were forwarded to the legal team.

On Monday morning, IPCC Legal Officer Sophie Schlingemann reported no limitations to citing approved and accepted reports, including IPCC reports. Saudi Arabia reiterated her call for the SROCC SPM to cite all knowledge gaps in SR15 if it is referenced.

Following further consultations, text was agreed that refers to actions that are most successful under the lowest level of warming, while explaining that coral reef restoration options may be ineffective if global warming exceeds 1.5°C, as corals are already at high risk.

C2.3: In response to a request by Spain in a paragraph on **strengthening precautionary approaches and responsiveness of existing fisheries management strategies**, authors restored earlier draft language on approaches “such as rebuilding overexploited or depleted fisheries.” The paragraph was agreed with this addition.

C2.4: Regarding a paragraph that states that **restoration of vegetated coastal (“blue carbon”) ecosystems assists in mitigation**, Norway, supported by the UK and Grenada, noted the need to restore and protect such ecosystems even if they do not significantly contribute to mitigation. The UK requested language

on co-benefits, including improving coastal communities' resilience, coastal protection and water quality. Brazil, supported by Spain, asked whether an internationally accepted definition of "blue carbon" exists. Co-Chair Roberts sent the paragraph to a huddle with the authors, who presented a revised text, which was accepted.

C2.5: A new paragraph, which addresses **ocean renewable energy**, was proposed by the UK, and supported by Ireland, Germany, Estonia, Spain, Luxembourg, the US, Chile, Norway, Belgium, and Mexico. Saudi Arabia questioned the rationale for its insertion. The UK explained that it followed from the previous paragraph's discussion on the role of the ocean and cryosphere in adaptation. In response to a suggestion from the US, text was added to note that the potential of renewable energy production from the ocean may be affected by climate change, and the paragraph was accepted.

C2.6: A paragraph on **integrated water management approaches** was modified to reflect that such approaches can be effective at addressing impacts across multiple scales.

C3: The subsection addresses **responses in coastal communities**. The headline statement was agreed as presented.

C3.1: Regarding a paragraph on **coastal protection**, the authors, upon request from India and Switzerland, qualified a sentence on hard protections as cost-efficient response options with language to ensure that specific contexts are considered.

C3.2: This paragraph discusses **the viability of various types of coastal accommodation measures**. Tanzania, supported by India, objected to the term "accommodation measures." Authors noted that the term is standard in the literature and is a response category in AR5 but added an illustrative example of such measures to improve clarity. Trinidad and Tobago asked for the word "retreat" to be recast as "planned relocation" as in the glossary, which was agreed. Saint Kitts and Nevis, supported by Trinidad and Tobago, Jamaica, and Belize, objected to language that implied that coastal retreat was an option, arguing that it is only an option when suitable and safe land is available. Following huddle discussions and presentation of revised text that responded to these requests, the paragraph was agreed without further comment.

C3.3: A paragraph on **governance challenges in responses to sea level rise and associated risk reduction** was slightly modified to include a suggestion by Saudi Arabia to add "intra-generational" alongside "inter-generational" equity.

C3.4: On a paragraph on **planning and implementing coastal responses to sea level rise**, the EU proposed to add, as an example of stakeholders with higher risk tolerance, reference to "those planning for investments that can be very easily adapted to unforeseen conditions." With this change and other minor changes for clarification, the paragraph was agreed.

Figure SPM.5: Sea Level Rise Risk and Responses: Delegates commented on four panels in this figure. During initial discussions, Saint Kitts and Nevis, Trinidad and Tobago, Jamaica, Fiji, the Maldives, and Grenada, supported by the UK, called for renaming a category of "high adaptation" as "maximum theoretically possible adaptation potential," to acknowledge the many obstacles to adaptation. Trinidad and Tobago said some islands can only achieve adaptation through risk reduction. Belize, with Grenada, recalled that coral restoration is impossible beyond 1.5°C. Canada suggested specifying that the range of responses shown is not comprehensive.

Saudi Arabia, *inter alia*: queried a new term "resource-rich megacities"; noted that "no-to-moderate adaptation" covers a wide range of adaptation scenarios; and questioned financial feasibility.

Fiji, with Grenada and the Maldives, said migration and relocation relates to loss and damage and depends on sufficient land availability. The US, conversely, emphasized the importance of relocation and rebuilding for city planners and others.

Co-Chair Pörtner called for a huddle, facilitated by IPCC Vice-Chair Ko Barrett, following which authors presented their proposed changes on Sunday afternoon, which, *inter alia*:

- differentiate between adaptation and relocation in the panel on risks in 2100, to cover forced migration;
- replace "high adaptation" with "maximum potential adaptation;"
- include a clarification that curves representing risk reduction and time gained through adaptation and mitigation in different contexts use sea level rise as a proxy for the shape of the overall risk curves; and
- in a panel on responses to rising mean and extreme sea levels, delete a reference to "coastal adaptation and retreat" from the title and separate "displacement" from "relocation."

New Zealand, supported by Norway, opposed eliminating retreat as an adaptation option, suggesting retreat be split into two rows, one on forced retreat and one on retreat as an adaptation option. The US noted the need for better information on how to manage retreat.

WG II Vice-Chair Sergey Semenov asked why confidence levels were only given for effectiveness of response options.

The UK questioned use of sea level rise as a proxy for other impacts, and noted that high adaptation involves significant expenditure, which is a barrier. Germany suggested explicitly acknowledging that costs are not considered for high adaptation.

Grenada called for reflecting in the caption that events such as tropical cyclones are not considered, meaning risks would be significantly higher if they were.

Co-Chair Pörtner called for a huddle, facilitated by WG II Vice-Chair Jacqueline Pereira, following which authors presented a third iteration of Figure SPM.5. WG II Vice-Chair Semenov called for the addition of a legend explaining what the different levels of risk actually entail.

Following further huddle discussions, authors explained additional changes, including with:

- "retreat" as a response broken down into the subcategories of "planned relocation" and "forced displacement";
- a focus on "responses" rather than "adaptation"; and
- renaming the panel on risk reduction and time gained through adaptation and mitigation to focus on benefits of responses to sea level rise and mitigation, with no use of a proxy.

The figure and the caption were both approved with no further discussion.

Enabling Conditions: C4: This section addresses **enablers for implementing effective responses to ocean and cryosphere change**. Norway requested that data and knowledge sharing be added to the list of enablers. Saudi Arabia objected strongly to the inclusion of SR15 in the line of sight. Following initial comments, the paragraphs in this subsection were further discussed in a contact group, after which a sentence was inserted into the headline statement, noting that the report "reflects the state of science for oceans and cryosphere for low levels of global warming (1.5°C), as also assessed in earlier IPCC and IPBES reports."

C4.1: In a paragraph addressing **adaptation challenges**, Saudi Arabia argued that any reference to SR15 would have to be accompanied by a full description of its knowledge gaps.

The US:

- requested the inclusion of language explaining why adaptation will be challenging and asked whether it was solely an issue of capacity;
- objected to use of the term “adaptation limits,” arguing that this assumes such limits are a known quantity, when in fact they are highly context specific;
- expressed concerns regarding reference to “ambitious” mitigation, noting this must also be defined in each unique national context; and
- noted that a sentence describing transformations as “necessary” was policy prescriptive and should be revised.

Following further revisions in the contact group that reflected most of the concerns expressed, except that of the US regarding reference to “ambitious” mitigation, the paragraph was approved without additional comment.

C4.2: This paragraph covers cooperation and coordination among governing authorities as a facilitator of adaptation.

Saudi Arabia said that a sentence on consistency between national and transboundary regional policies was too policy prescriptive. Following contact group discussions, the sentence was revised to include reference to “coordination and complementarity,” instead of “consistency.” The paragraph was approved with this change.

C4.3: A paragraph on the enabling influence of taking a long-term perspective when making short-term decisions was approved as presented.

C4.4: A paragraph on investments in education and capacity building to reduce risk and enhance resilience was modified with the replacement of adaptive governance “arrangements” instead of “systems,” as proposed by Saudi Arabia, for consistency with previous paragraphs. With other minor modifications, the paragraph was agreed.

C4.5: This paragraph addresses monitoring and forecasting of changes in the ocean and cryosphere. Text was added based on interventions from Switzerland (on sharing of data), Haiti (on information and knowledge) and Fiji (improved early warning systems to predict extreme El Niño/La Niña events and tropical cyclones). The paragraph was approved with these additions.

C4.6: This paragraph discusses prioritizing measures to address social vulnerability and equity. There were calls to stress the need for meaningful participation and deliberation, and for significantly increased national and international climate finance. Authors were amenable to the former and text was amended to reflect this, but they cited lack of support in the underlying literature to include reference to climate finance. The paragraph was then agreed.

C4.7: This paragraph addresses benefits of ambitious mitigation and effective adaptation for sustainable development, and escalating costs and risks of delayed action. The draft text noted that the SROCC reinforces the findings of SR15, SRCCL, and the IPBES Global Assessment Report on Biodiversity and Ecosystem Services. When it was first taken up in plenary on Monday, Saudi Arabia strongly objected to referencing other IPCC reports from the current assessment cycle, as well as to language on potential climate resilient development pathways and on unprecedented mitigation efforts. The US again objected to characterizing mitigation as ambitious. WG I Vice-Chair Panmao Zhai forwarded the text, along with other paragraphs in this subsection, to the contact group.

The results of the contact group discussions were brought back to plenary on Tuesday. Saudi Arabia again strongly objected to any reference to other IPCC SRs, in particular SR15, which remained in the revised version of the paragraph. The

Russian Federation also favored dropping the reference. Many countries, including France, Germany, Mexico, Saint Kitts and Nevis, the Netherlands, Canada, Luxembourg, and the UK, objected, stressing the importance and relevance of SR15 and the incongruence of IPCC not citing its own work.

A long discussion ensued in both plenary and huddles, with Saudi Arabia stating willingness to “go the procedural route” and do what they had done in Kyoto for the 2019 Refinement, when their reservation was recorded in the report and the relevant decision. To avoid this, many formulations were proposed to describe the relationship between the SROCC and SR15, SRCCL, and the IPBES Global Assessment Report on Biodiversity and Ecosystem Services, including “reinforces,” “reflects,” “expands on,” “is consistent with,” and “also found in earlier IPCC reports.”

The Russian Federation agreed to a formulation proposed by WG II Co-Chair Pörtner stating that “this assessment reinforces findings for low levels of global warming (1.5°C) and the IPBES Global Assessment Report on Biodiversity and Ecosystem Services” and removing SR15 and SRCCL from the line of sight. Instead, Saudi Arabia proposed stating that “This assessment notes the findings for low levels of global warming (1.5°C), acknowledging scientific and knowledge gaps associated with this report.”

Canada cautioned that this type of discussion would deter the scientists on which IPCC depends from participating in the Panel’s future work for fear the scientific integrity of their work could not be assured.

Eventually the authors expressed their preference to delete the sentence as they believed a similar message was conveyed elsewhere in the SPM. With this, the paragraph was agreed.

Final SPM Text: Section C addresses the implementation of responses to ocean and cryosphere change.

Subsection C1 addresses challenges to current governance efforts in responding to climate-related impacts to the ocean and cryosphere, and notes that:

- long-term temporal scales of climate change impacts and the shorter time horizons of many governance arrangements (1.5°C) are mismatched;
- governance arrangements for oceans and the cryosphere are challenged by administrative boundaries that do not match boundaries of affected areas or impacts, with a lack of the integration across sectors and responsibilities that is necessary to address systemic effects;
- adaptation in ecosystems is challenging for many reasons, including the variety of non-climatic drivers involved, climate-related reduction in ecosystem adaptability and recovery rates, and limits in availability of technology, knowledge, and financial support; and
- people with highest exposure and vulnerability to current and future hazards from ocean and cryosphere changes are often those with lowest adaptive capacity, particularly in low-lying islands and coasts, Arctic, and high mountain regions with development challenges.

Subsection C2 addresses responses available to support services and options provided by ocean and cryosphere-related ecosystems, and stresses that:

- networks of protected areas can help maintain ecosystem services and enable future ecosystem-based adaptation options;
- terrestrial and marine habitat restoration and ecosystem management (such as coral gardening) can be locally effective in enhancing ecosystem-based adaptation, although such policies lose effectiveness under high emissions scenarios;

- precautionary approaches in areas such as fisheries management policies will benefit regional economies and livelihoods, although they have limited ability to address underlying ecosystem change;
- restoring vegetated coastal ecosystems such as seagrass meadows, kelp forests, and mangroves could absorb up to 0.5% of current global CO₂ emissions, as well as providing storm protection, improving water quality, and benefiting biodiversity and fisheries;
- ocean-based renewable energy options can contribute to mitigation;
- integrated water management approaches can be effective in addressing impacts and leveraging opportunities from cryosphere changes in high mountain areas; and
- diversification of tourism activities supports adaptation in high mountain economies.

Subsection C3 addresses the **challenging choices coastal communities face in crafting context-specific and integrated responses to sea level rise**. It states that:

- the higher the sea levels rise the more challenging is coastal protection, mainly due to economic, financial, and social barriers rather than technical limits;
- some coastal accommodation measures are often both low-cost and highly cost-efficient given current sea levels, while under projected sea level rise and increase in coastal hazards some measures become less effective unless combined with other measures;
- where the community affected is small, or in the aftermath of a disaster, reducing risks by coastal planned relocation is worth considering if safe alternative localities are available, but such relocations can be constrained by a variety of challenges;
- responses to sea level rise and associated risk reduction present society with profound governance challenges resulting from uncertainty about the magnitude and rate of future sea level rise and other challenges, but these can be eased using locally appropriate combinations of approaches that are adjusted over time as circumstances change; and
- many coastal decisions with time horizons of decades to over a century are being taken now and can be improved by considering the risk tolerance of stakeholders.

Section C also contains **Figure SPM.5**, on sea level rise risk and responses. This figure shows, over four panels, the risk in 2100 under different sea level rise and response scenarios, benefits of responses to sea level rise and mitigation, responses to rising mean and extreme sea levels, and choosing and enabling sea level rise responses.

Subsection C4, discusses the urgent and ambitious emissions reductions, coupled with coordinated sustained and increasingly ambitious adaptation actions, upon which **enabling climate resilience and sustainable development** critically depends. It states that:

- many nations face adaptation challenges, even with ambitious mitigation, in light of observed and projected changes in the ocean and cryosphere, but low emission pathways will limit risks and enable more effective response;
- intensifying cooperation and coordination among governing authorities across scales, jurisdictions, sectors, policy domains, and planning horizons can enable effective responses to changes in the ocean and cryosphere and to sea level rise;
- experience to date reveals the enabling influence of taking a long-term perspective when making short-term decisions and building governance capacity to tackle complex risks;

- investments in education and capacity building at various levels and scales facilitate social learning and long-term capability for context-specific responses to reduce risk and enhance resilience;
- context-specific monitoring and forecasting of changes in the ocean and cryosphere inform adaptation planning and implementation, and facilitate robust decisions on trade-offs between short- and long-term gains;
- prioritizing measures to address social vulnerability and equity underpin efforts to promote fair and just climate resilience and effective adaptation for sustainable development; and
- the potential to chart Climate Resilient Development Pathways varies within and among ocean, high mountain, and polar land regions and depends on transformative change, which highlights the urgency of prioritizing timely, ambitious, coordinated, and enduring action.

Closing of the Second Joint Session of WGs I and II

On Tuesday morning, the Second Joint Session of WGs I and II approved the SPM and accepted the underlying report and forwarded everything to the IPCC Plenary. The Joint Session closed at approximately 11:00 am.

Acceptance of the Actions Taken at the Second Joint Session of WGs I and II

When IPCC-51 resumed Tuesday afternoon, IPCC Chair Lee invited the Panel to approve the SPM (IPCC-LI/Doc. 3) and accept the Underlying Scientific-Technical Assessment and a number of small changes (IPCC-LI/Doc.4) to ensure consistency with the SPM.

The US stated that its acceptance of the SROCC does not imply endorsement of its findings because it is not subject to line-by-line approval by the Panel.

Belgium called for reducing the length of SPMs, for greater ease of approval, assurance of accuracy, and acceptance by policymakers.

The Republic of Korea said SROCC will be a critical component in understanding the effects of climate change.

WG I Co-Chair Valérie Masson-Delmotte acknowledged the benefits of the cross-WG nature of the work but denounced the heavy workload involved with the completion of three SRs in less than one year. She asked that such a heavy workload not be imposed on WG Co-Chairs, Vice-Chairs, and TSUs ever again.

Chair Lee added that undertaking three SRs in one cycle was a first for the IPCC.

Progress Report of the Task Group on the Organization of the Future Work of the IPCC in Light of the Global Stocktake

María Amparo Martínez Arroyo, Co-Chair, Task Group on the Organization of the Future Work of the IPCC in light of the Global Stocktake under the Paris Agreement, presented an oral progress report on the Task Group's work. She said governments had been asked to provide input on goals for future work and a meeting on these was held during IPCC-50, which drew 21 countries and two NGO representatives. She announced that a preliminary analysis of received responses was now complete. She noted use of an electronic consultative process in order to address the need for broad consultation and said a meeting will be held in Singapore in October on the sidelines of the IPCC Bureau meeting to discuss the Task Group's progress and activities, with a final report to be presented at IPCC-52.

Saudi Arabia expressed appreciation for work done and reiterated that the assessment should be qualitative, not statistical. He said Saudi Arabia is not in favor of “sully” the IPCC with the politics of a different process and expressed satisfaction with the way the IPCC does science free from the pressure of other bodies.

The Panel took note of the progress report.

Report of the IPCC Conflict of Interest Committee

Youba Sokona, IPCC Vice-Chair and Conflict of Interest Committee Chair, reported that no conflict of interest had been identified. The Panel took note of the report.

Any Other Business

Update on Preparations for the SYR Scoping Meeting: On Tuesday afternoon, IPCC Chair Lee reported on progress since IPCC-50 in preparing for the SYR scoping meeting, scheduled to take place from 21-23 October 2019 in Singapore. He noted that the Scientific Steering Committee for the SYR scoping meeting has convened five times to date and promised that a detailed agenda for the scoping meeting will be made available in the next few weeks. He pointed out that in response to a 23 April 2019 letter inviting governments to nominate participants for the meeting, the Secretariat received 549 nominations for a total of 80 available positions. On 30 June, he asked the WG Co-Chairs for their recommendations, and the process of confirming the final selected candidates was now underway.

France asked about the vision for cooperation between the team that is preparing the scoping and the WGs, noting the exceptional burden the latter are under during the sixth assessment cycle.

In response to a question from the UK, Chair Lee noted that the initial nominations for the scoping meeting included 52% from developing countries, 34% women, and 74% from research institutes. He said 13% were from government institutions, with the remaining 87% a combination of representatives from non-governmental and intergovernmental organizations and the private sector.

China stressed that focal points are eager to hear about the status of their nominees, and Tanzania, supported by the US, asked that those that are not chosen be notified as well. Chair Lee confirmed that this would take place and promised a full report at IPCC-52.

Update on Translation and Publication of SR15: Chair Lee reported on progress on translation of SR15 into the six UN languages.

WG I Co-Chair Masson-Delmotte expressed extreme frustration that almost a year after the SR15 was finalized an official French translation is still not available and has not been published, meaning that authors are not able to cite it. She said a group of citizen-translators had produced what is still the only French translation online, and it is being used in Africa. Jonathan Lynn, Head, Communications and Media Relations, reported that the translation is currently going through the WMO contracting process.

France echoed WGI Co-Chair Masson-Delmotte’s statement, noting its sensitivity to this issue because France funds the WG I TSU. He said referenceable digital and hard copies are needed.

Progress Report of TG-Data: An oral progress report was presented on TG-Data, noting an amendment to the Task Group’s terms of reference to enable the IPCC Bureau to nominate TG-Data members and that the first face-to-face meeting will take place from 6-8 November 2019.

Closing Plenary

IPCC Secretary Abdalah Mokssit announced that IPCC-52 would likely convene from 24-28 February 2020 in Geneva. Following interventions from the US and IPCC Financial Task Team Co-Chair Helen Plume regarding cost concerns with respect to holding meetings in Geneva, Mokssit said that other options were under discussion and additional information would be forthcoming as soon as possible.

In closing, IPCC Chair Lee thanked everyone for their uncompromising commitment to scientific rigor while pursuing balance, during one of most ambitious years in the IPCC’s history. He thanked Monaco for providing inspiration for the SROCC and said its contents would be shared at COP 25 in Santiago, Chile. He thanked the Secretariat, the interpreters, and everyone for their hard work. Chair Lee gavelled the meeting to a close at 1:59 pm.

A Brief Analysis of IPCC-51

“The sea, the great unifier, is man’s only hope. Now, as never before, the old phrase has a literal meaning: we are all in the same boat.” Jacques Yves Cousteau

On Friday, 20 September 2019, as the Intergovernmental Panel on Climate Change (IPCC) gathered in Monaco for its 51st session, more than four million people took to the streets around the world to demand action on climate change. “United behind the science,” was one of the slogans used by demonstrators. Four days later, after an all-night session, scientists themselves united as the Panel finalized its Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). A total of 104 scientists from 36 countries reviewed almost 7,000 papers and prepared an assessment to inform the public, in particular decision makers, on the impacts of climate change on the oceans, ice sheets, and glaciers.

The news is not good. Human-induced climate change is already resulting in increased marine heatwaves, ocean acidification, sea level rise, and glacier and permafrost melting—all with dire consequences for plants and animals, ecosystems and millions of people. These impacts are expected to continue and intensify, even under the lowest mitigation scenarios. The pace of change is now so rapid that the IPCC assessment, with its strict scientific integrity guidelines to cover peer-reviewed literature and the need for observations to be clearly linked to anthropogenic climate change, is undoubtedly on the conservative side.

This brief analysis examines the IPCC meeting in Monaco, highlighting the key findings of the SROCC as well as the process of approving its SPM, and contemplates the report’s place in the broader context of the ongoing IPCC and UNFCCC processes to address climate change.

The SROCC: Why and How

Oceans and ice cover more than 80% of the earth’s surface and are an integral and dynamic part of the earth’s climate systems. As such, the SROCC is critical to understanding the story of our planet’s changing climate. The ocean has absorbed 90% of the excess heat of the past decades, with consequences now visible in increased ocean acidification, stratification, and loss of oxygen. These effects have, in turn, led to more rapid ice sheet and glacier melting, sea level rise, increases in the frequency, intensity, and duration of extreme weather events, and ecosystem disruption with attendant effects visited especially on coastal and snow- and ice-dependent populations, many of whom are among the most vulnerable and least resilient population groups in the world.

The changes are widespread and unprecedented. They are expected to continue, with ever more intensity, in the coming years. And the costs of dealing with them will only increase the longer action is delayed.

The SPM is a summary that draws out the key messages of the more technical longer underlying report. Drafting of the report and summary is a highly interactive process, and the drafts that formed the basis for discussion in Monaco at IPCC-51 had already addressed more than 31,000 comments from expert reviewers and governments. Only at that point did the SPM face the collective review of governments in a line-by-line approval process. The process involves representatives of every country in the room directly posing questions to the authors, who are forced to check and double-check the scientific basis for each statement in the SPM.

In Monaco, discussions centered on how to present the findings, with government comments generally focused on the clarity and traceability of messages. In many ways the exercise is in stark contrast to how scientists usually work, carefully expressing the details of their research so as to ensure replicability. This is very different from drafting clear messages that highlight key findings and their potential implications in a way that policymakers can understand and use as a basis for action.

In many ways the SPM approval process boils down to a process of translation for which few scientists have been trained: translating technical details such as the difference between scenarios used or the complex dynamics of ocean-atmosphere interactions into language that can be readily understood by policymakers while still staying true to the underlying science.

The meeting in Monaco saw many instances of this translation. Some were simple word corrections—for example, instead of saying that ocean warming “has synergistic interactions with overfishing,” say “compounding negative impacts from overfishing.” Others amounted to pleas to make the findings relevant to the real-world political challenges of decision-makers. During the SROCC review, for example, the authors were asked to recast the “coastal retreat” of climate-affected populations in a way that reflects some hard facts: in all cases it will be challenging, in some cases it might be a forced displacement rather than a planned relocation, while in still other cases, for example in small, densely populated islands, it will simply be impossible.

After this intensive exercise, many participants agreed that the report was more readable, accurate, and relevant. The science was scrutinized but not questioned, and the main controversies responded to the perceived political weight that certain references might carry under the United Nations Framework Convention on Climate Change (UNFCCC). The request by Saudi Arabia to remove reference to the IPCC Special Report on Global Warming of 1.5 °C (SR15) was deemed by some participants to result from a misplaced legalistic approach to a summary of scientific findings. Yet, as one participant noted, using a Spanish phrase, this amounted to trying to “block out the sun with an upraised thumb.”

In end, the SPM was approved by all, thanks largely to the heroic efforts of the four Working Group Co-Chairs who, after a 24-hour marathon, achieved consensus. This avoided repeating the procedural outcome from IPCC-49, under which Saudi Arabia was recorded as not having fully accepted the 2019 Refinement to the 2006 Guidelines on National GHG Inventories. Repeated in Monaco, such a result would have risked spillover problems in the UNFCCC, where the SROCC could have been challenged as a legitimate basis for informing negotiations. The ultimate

consensus on approval also owed much to the flexibility shown by the authors who were patiently open to changes in their text that did not compromise the scientific integrity of their findings—integrity on which the IPCC depends. As expressed by IPCC Vice-Chair Ko Barrett (quoting the SPM) at the close of the Joint Session of Working Groups I and II, their attitude displayed the need to “prioritize timely, coordinated and ambitious action,” beyond words.

Connections (and disconnections) to the Wider Process

The SROCC is really one piece of a larger whole, and it is important that it be seen alongside the other Special Reports prepared by the IPCC this year: the SR15 on the impacts of global warming at 1.5 °C; the Special Report on Climate Change and Land; and even the Refinement to the 2006 Guidelines for GHG Inventories. Along with its sister reports, SROCC is a critically important part of the sixth assessment cycle and its Sixth Assessment Report (AR6) on current knowledge of climate change, its impacts, and adaptation and mitigation options. The AR6 in turn will inform the ongoing revision of UNFCCC parties’ pledges for action under the Paris Agreement (Nationally Determined Contributions, or NDCs), the new iterations of which are expected to show increased levels of ambition. The SROCC, as part of the wider constellation of IPCC work, ensures that those updated pledges will be informed by a much richer, deeper understanding of the science—an understanding that must underlie any appropriate climate policy.

But the SROCC also raises the problem of disconnection, in particular the temporal mismatch between the effects of GHG concentrations in the oceans and the atmosphere—spanning decades and centuries—and the short time horizon and planning cycles of decision-making under most current governance arrangements. This is reflected in the more glaring disconnect between the massive public call for action, as displayed in Friday’s demonstration led by young people, and the largely lackluster declarations of governments at the UN Climate Action Summit on the following Monday.

Outcomes and Impacts

One of the most useful outcomes of IPCC assessments is the identification of knowledge gaps. These tend to be found in developing countries and small island developing states and remote areas where too little science is focused, compounding the irony that they are the most vulnerable to the impacts of climate change. Given their global coverage and well-documented assessment process, the IPCC reports allow scientists to identify the areas and regions where research is most needed.

In this sense, it was fitting that the young scholars from developing countries who have been awarded the IPCC scholarship were honored during a welcoming ceremony hosted by HS Prince Albert II of Monaco on the night before the IPCC-51 began. These are the scholars that will carry forward the necessary scientific work. These young scientists will in turn be supported by people demanding action, which, as the Friday demonstrations made clear, now span the globe, cutting across developed and developing countries.

During her intervention at the UN Climate Action Summit, Greta Thunberg said that “Change is coming whether you like it or not.” The IPCC SROCC makes it clear that, with regard to the ocean and cryosphere, change is already here and will only get worse. In Monaco the IPCC did its part to ensure that the change she is talking about, toward public understanding and hopefully effective action, is also coming.

Upcoming Meetings

IPCC WG III AR6 Second Lead Author Meeting: The second Lead Author meeting of IPCC Working Group III will convene to continue preparations for the AR6. **dates:** 30 September - 4 October 2019 **location:** New Delhi, India **www:** <http://www.ipcc.ch/calendar>

Marine Regions Forum 2019: Convening under the theme “Achieving a healthy ocean - Regional ocean governance beyond 2020,” the Marine Regions Forum aims to develop clear recommendations, catalyze actionable outputs, and build partnerships for stronger regional ocean governance in support of SDG 14 “Life Below Water.” The Forum will provide a space for decision-makers, scientists, and civil society from around the world to discuss solutions for ocean health. **dates:** 30 September - 2 October 2019 **location:** Berlin, Germany **www:** <https://www.prog-ocean.org/marine-regions-forum/>

34th Meeting of the Adaptation Fund Board: The Adaptation Fund (AF), established under the Kyoto Protocol, finances projects and programmes that help vulnerable communities in developing countries adapt to climate change. The Fund is supervised and managed by the AFB, which is composed of 16 members and 16 alternates and convenes meetings throughout the year. The World Bank serves as AF trustee on an interim basis. **dates:** 7-11 October 2019 **location:** Bonn, Germany **www:** <https://www.adaptation-fund.org>

2019 Arctic Circle Assembly: This meeting brings together heads of state and government, ministers, members of parliaments, officials, experts, scientists, entrepreneurs, business leaders, indigenous representatives, environmentalists, students, activists, and others interested in the future of the Arctic. **dates:** 10-13 October 2019 **location:** Reykjavik, Iceland **www:** <http://www.arcticcircle.org/assemblies/future>

SYR Scoping Meeting: A scoping meeting for the SYR for the IPCC Sixth Assessment Report will take place in Singapore. This will be followed by the 57th session of the IPCC Bureau. **dates:** 20-23 October 2019 **location:** Singapore **www:** <https://www.ipcc.ch/calendar/>

Our Ocean Conference 2019: The sixth Our Ocean Conference will highlight the importance of knowledge as the basis of our actions and policies to ensure sustainable future economic growth. The conference will bring together leaders from government, business, civil society, and research institutions to share their experience, identify solutions, and commit to action for a clean, healthy, and productive ocean. **dates:** 23-24 October 2019 **location:** Oslo, Norway **www:** <https://ocean2019.no/>

10th Meeting of the Executive Committee of the Warsaw International Mechanism for Loss and Damage: The tenth meeting of the Executive Committee (ExCom) of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts will guide the implementation of the functions of the mechanism. **dates:** 23-25 October 2019 **location:** Bonn, Germany **www:** <https://unfccc.int/wim-excom>

WMO High Mountain Conference: This meeting aims to foster high-level dialogue and engage decision makers and local actors to develop a roadmap to science-based, user-driven knowledge and information systems supporting sustainable development and risk reduction in mountain and downstream regions. It is being convened by WMO. **dates:** 29-31 October 2019 **location:** Geneva, Switzerland **www:** <https://highmountainsummit.wmo.int/en>

Santiago Climate Change Conference (UNFCCC COP 25): The Santiago Climate Change Conference, which will feature the 25th session of the Conference of the Parties (COP 25) to

the UNFCCC, the 15th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP 15) and the 2nd session of the Conference of the Parties serving as the Meeting of the Parties to the Paris Agreement (CMA 2), will convene along with meetings of the UNFCCC subsidiary bodies. The pre-session period will be from 26 November - 1 December 2019. **dates:** 2-13 December 2019 **location:** Santiago, Chile **www:** <https://unfccc.int/santiago>

IPCC WG II AR6 Third Lead Author Meeting: This third Lead Author meeting of WG II will convene to continue preparations for the AR6. **dates:** 27-31 January 2020 **location:** TBD **www:** <http://www.ipcc.ch/calendar>

IPCC-52: This meeting is currently scheduled to meet in Geneva. However, other options are being explored. **dates:** 24-28 February 2020 (TBD) **location:** Geneva, Switzerland (TBD) **www:** <http://www.ipcc.ch/calendar>

For additional meetings, see <http://sdg.iisd.org>

Glossary

AMOC	Atlantic Meridional Overturning Circulation
AR6	Sixth Assessment Report
COP	Conference of the Parties
GHG	Greenhouse gases
GMSL	Global mean sea level
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally Determined Contribution
RCP	Representative Concentration Pathway
SIDS	Small island developing states
SPM	Summary for Policymakers
SR	Special Report
SR15	Special Report on Global Warming of 1.5 °C
SRCCCL	Special Report on Climate Change and Land
SROCC	Special Report on the Ocean and Cryosphere in a Changing Climate
SYR	Synthesis Report
TG-DATA	Task Group on Data Support for Climate Change Assessments
TSU	Technical Support Unit
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WG	Working Group
WMO	World Meteorological Organization